

NORTH AMERICAN PARASITIC COPEPODS BELONGING TO THE NEW FAMILY SPHYRIIDAE.

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INTRODUCTION.

This is the fifteenth ¹ paper in the series dealing with the parasitic-copepods in the collection of the United States National Museum, and comprises a new family to be called the Sphyriidae.

The genera of this family are closely related to the Lernaeidae, but differ in their life history and in several important morphological characters. Instead of disappearing after the copepodid stages, as in the Lernaeidae, the male persists as a pigmy adult, attached to the body of the female, as in the Lernaeopodidae. Hence sexual maturity is not reached during the last copepodid stage, and both sexes are subsequently changed greatly in body form and structure. Similarly fertilization does not take place previous to the attachment of the female to her host, but after that event and the metamorphosis which follows it, and the spermatophores are attached to the vulvae in the usual manner. The females become even more grotesque and bizarre than those of the Lernaeidae, so that in spite of their paucity of species the genera surpass all the other parasitic copepods in morphological transformations. It is to be regretted that no material is available for the life history of any of the genera, since it probably differs in several essential particulars from any yet recorded. But unfortunately all the species are parasites of fish which frequent the open ocean, and the great majority of which are found only at considerable depths. Consequently the developmental stages are very difficult of access, and the

¹ The 14 preceding papers, all of which were published in the Proceedings of the United States National Museum, are: 1. The Argulidae, vol. 25, pp. 635-742, pls. 8-27. 2. Descriptions of Argulidae, vol. 27, pp. 627-655, 38 text figures. 3. The Calliginae, vol. 28, pp. 479-672, pls. 5-29. 4. The Trebinae and Euryphorinae, vol. 31, pp. 669-720, pls. 15-20. 5. Additional Notes on the Argulidae, vol. 32, pp. 411-424, pls. 29-32. 6. The Pandarinae and Cecropinae, vol. 33, pp. 323-490, pls. 17-43. 7. New Species of Calliginae, vol. 33, pp. 593-627, pls. 49-56. 8. Parasitic Copepods from Pacific Coast, vol. 35, pp. 431-481, pls. 66-83. 9. Development of *Achtheres ambloplitis* Kellicott, vol. 39, pp. 189-226, pls. 29-36. 10. The Ergasilidae, vol. 39, pp. 263-400, pls. 41-60. 11. Descriptions of New Genera and Species, vol. 39, pp. 625-634, pls. 65-68. 12. Descriptions of New Species, vol. 42, pp. 233-243, pls. 30-34. 13. The Lernaeopodidae, vol. 47, pp. 565-729, pls. 25-56. 14. The Lernaeidae, vol. 53, pp. 1-150, pls. 1-21.

chances are all against their acquisition. We must be satisfied, therefore, with the morphological and structural details of the adults.

The material for the present paper was derived from several sources. The first and by far the most important one was the collection of the United States National Museum, which included the new genus *Periplexis* and the various species of *Rebelula* and *Sphyrion*. Then a number of drawings have been generously placed at the author's disposal, including a fine series by Dr. Richard Rathbun and two drawings by J. H. Blake on *Sphyrion lumpi*, a second series by Rathbun and a single drawing by Blake on *Rebelula bouvieri*, a single drawing by Blake of the new species, *Rebelula gracilis*, and two drawings of the new genus *Periplexis* by A. H. Baldwin.

These drawings by Blake and Baldwin were made in 1882 and 1887, and it is fortunate that they are finally to be published.

The specimens of the genus *Opimia* were obtained by Dr. J. C. McClendon from a shark at La Jolla, California, while those of both species of the new genus *Paeon* were obtained by the present author from sharks at Beaufort, North Carolina, while in the employ of the United States Bureau of Fisheries.

In the examination of specimens the same methods have been used as in the Lernaedidae; they were dehydrated in absolute alcohol and cleared in clove oil, or better still in oil of wintergreen. In consequence they became so transparent that the internal anatomy was visible in all its details. The pigmy males, after such treatment, were mounted *in toto* in Canada balsam on culture slides and are preserved in this manner.

Serial sections have also been made of one of the partially developed females of *Sphyrion lumpi*, thus supplementing the work with the cleared specimens.

As here constituted the family is made up of six genera, two of which, *Periplexis* and *Paeon*, are new to science, and 14 species, of which the females of five are new, as well as all the males.

HISTORICAL.

Quoy and Gaimard seem to have been the first to discover any of the species belonging to this family. They figured and described in the report of Freycinet's voyage around the world (1824) a parasite which they referred to the genus *Chondracanthus*, and to which they gave the French name "lisse." Cuvier (1830) recognized that this species did not belong to the genus *Chondracanthus*, and with it as a type he established the new genus *Sphyrion* (vol. 3, p. 257). Guérin (1829-1844) translated the French name "lisse" into the Latin equivalent *laevigatus* (vol. 2, pl. 9, fig. 4), but added nothing further to the description.

Burmeister (1823) did not include the genus in his family "Penellina" because he was unacquainted with any of the species, but in a footnote (p. 319) he said that *Sphyrion laevigatus* evidently formed a valid genus between *Lernaea* and *Lernaeocera*.

Milne Edwards (1840) claimed that the genus *Sphyrion* was too imperfectly known to be located definitely, but that it probably ought to be placed between the "Penelles" and the "Lernées" (p. 525).

Steenstrup and Lütken (1861), judging from the figures published by Quoy and Gaimard, Guérin, and Cuvier, said that the genus did not belong with the Lernaeidae but with the Chondracanthidae (p. 432).

Krøyer (1845) found a similar species parasitic upon a lumpfish, but failed to recognize that it belonged to the genus *Sphyrion*, and created for it a new genus, which he called *Lestes*, with the species *lumpi* (p. 217). But the name *Lestes* had been used by Leach in 1817 for a genus of dragonflies and so Krøyer changed to the feminine *Lesteira* in 1863 (p. 325), when he gave a more detailed description of the species. This last name accordingly becomes a synonym of *Sphyrion*.

But Krøyer did not agree with Steenstrup and Lütken in placing the genus amongst the Chondracanthidæ; he was rather of the opinion that it belonged with the Lernaeocerans. Although his genus name has become a synonym his species was valid, and these two species, *laevigatus* and *lumpi*, were at first the only ones in the genus.

In describing the crustacea of the voyage of the *Nassau*, Cunningham (1871) added a third species of *Sphyrion*, to which he gave the name *kingi* (p. 501).

Thor (1900) had an opportunity of examining more in detail Quoy and Gaimard's type-specimen of *Sphyrion laevigatus*, but for some unexplained reason he preferred to call it "*laevis*" instead of *laevigatus* (p. 277). He also described and figured a species new to science, *S. australicus*, and mentioned another new species, *norvegicus*, without giving any figures or description. And finally Quidor (1912) added a new species *delagei* (p. XLI), and on the following page another new species, *stewarti*. He also on page XLIII described a new genus and species, *Hepatophylus bouvieri*. This new genus, together with *Sphyrion*, he placed in the Lernaeidae because they showed torsion, which he claimed was exhibited nowhere outside of that family. Bassett-Smith (1899) in his systematic Review of Parasitic Copepods (p. 489), and Stebbing (1900) in his South African Crustacea (p. 60), changed the gender of the specific name to agree with that of the genus, making it *laevigatum*.

In 1853 K  lliker created a new genus of parasitic copepods to which he gave the name *Lophoura*. This was described in great de-

tail and accurately figured by Cornalia in 1865. But the name *Lophoura* had been preoccupied by Fleming in 1822 for a genus of birds, and hence Poche in 1903 proposed the new name *Rebelula*, which has been adopted.

P. J. van Beneden discovered a parasite which he described and figured in 1851 as *Lernaeonema musteli*; this was renamed *Trypaphylum musteli* by Richiardi (1878), who added nothing to the description. But later T. and A. Scott (1913) supplemented the description of the female and added one of the male, with excellent figures of both sexes (p. 159, pl. 45, fig. 6; pl. 51, fig. 1; pl. 49, figs. 1-7).

ECOLOGY.

Sexual dimorphism.—The female sphyriid is a fixed parasite and has completely lost not only the power of locomotion but also the swimming legs and often most of the other appendages. Furthermore her body has been transformed in size and structure to a greater extent than in any other family of copepods. Consequently we find here very marked sexual dimorphism in locomotion, in prehension, and in morphology, which will be taken up under these headings respectively.

Locomotion.—Although we know nothing of the development of any genus in the family, we are safe in saying that the larvæ alone possess the power of free swimming, but we can only surmise for how long a period it continues. During this period, whatever its length may be, both sexes fasten upon their future host, after which their subsequent development varies greatly.

Female.—We are not obliged to suppose that the female eventually fastens to the first spot upon the fish's body that she happens to come in contact with. In all probability she can move about over the external surface and thus exercise a choice as to her final location. It may fairly be said that this is proved by the fact that so many of the species are found fastened near the base of the dorsal fin. It would hardly be possible for them all to hit that spot upon their first trial. The necessary locomotion over the surface of the body of the host is accomplished by means of the maxillæ and maxillipeds as in the male. But, having once reached a suitable and satisfactory location, and having commenced to burrow, all locomotion on the part of the female ceases and she becomes permanently fixed for life.

Male.—Similarly the male moves about over the surface of the host, and also over the body of the female, after he has once fastened to her. This movement is accomplished by means of the second maxillæ and maxillipeds, in a manner similar to that of the *Lernaeopod* male. In the genera *Rebelula* and *Sphyrion* the structure of the antennae shows them to be absolutely unfit to take any part in locomotion. And in *Paeon*, while the second antennae are furnished

with weak chelae, the appendages themselves are so small and short that they are not capable of doing any real work. The locomotion of the *Rebelula* male is doubtless greatly facilitated by the increased length of the basal joints of the maxillipeds. This makes possible a much longer reach between the second maxillae and the maxillipeds, and the male must be able to move about quite freely. The males retain the ability to perform this sort of locomotion during life. But after they have found their host, or after they have attached themselves to the body of the female, they lose their swimming legs, so that they are no longer capable of free swimming. These males thus go a step farther than those of the Lernaeopods, for the latter sometimes retain their swimming legs although they are no longer of any service as locomotor organs.

Prehension.—The organs of prehension are the same as those with which the parasite crawls about over the body of its host, namely the second maxillae and maxillipeds. And the male continues to use them for both purposes throughout life. Accordingly we find that these organs persist in the male, that they increase in size with the growth of the body, and that they retain a very well-developed set of muscles, which renders them efficient for both prehension and locomotion. But the female, after she has once burrowed into the tissues of the host, develops processes or horns, or both, upon the sides of the cephalothorax, which anchor her firmly in a fixed position, so that she has no further need for organs of prehension. And the maxillae and maxillipeds, thus rendered useless, entirely disappear, or if they persist they do not increase in size with the enormous increase of the female's body, and evidently do not function at all as prehensile organs.

Burrowing.—While the genera belonging to the Sphyriidae are much more limited in their choice of a point of attachment than those of the Lernaeidae, and while none of them, so far as yet known, ever burrows into the fish's heart, or penetrates the tissues of its host to anything like the distance accomplished by *Pennella*, nevertheless their burrowing is similar in all respects to that of the Lernaeidae, and is probably accomplished in the same manner. Fortunately a few of the specimens in the United States National Museum collection had been secured by cutting out a block of the tissues of the host large enough to include all of the parasite's head and neck. In this way it was possible to determine that the dorsal aorta was the blood vessel usually sought, and that, in reaching it, the parasite found the same difficulties noted in the Lernaeidae.¹ But in the present family the second antennae can not take as prominent a part in the burrowing as they did among the Lernaeids, and accordingly it must

¹ Proc. U. S. Nat. Mus., vol 53, p. 16.

be accomplished chiefly by the mouth parts. There is also an elongation of the thorax accompanying the burrowing, but it differs from that of the Lernaecids in one important particular. In the Lernaecidae, as is shown by the persistence of the swimming legs, close together and just behind the head, the elongation is produced by the fifth and sixth thoracic segments. The only exception is found in the genera *Peniculus* and *Lernaea*, in which the anterior segments of the thorax take part in the elongation. In the former genus, *Peniculus*, the second and third segments are slightly elongated, so that the four pairs of legs do not stand close together, but while the first and second pairs are still in juxtaposition, the third and fourth pairs are each removed to a little distance posteriorly. But even here the so-called neck ends with the third segment, and the remaining segments are fused into a common trunk. In *Lernaea* each thorax segment contributes its share to the elongation, and each pair of legs is removed from the one which precedes it by a distance which increases as we proceed backward, bringing the fourth legs close to the posterior end of the body. And there is often a fifth pair of rudimentary legs just over the bases of the egg strings, in a position corresponding to that found in the Caligidae. But there is no real neck, the anterior thorax passing insensibly into the posterior, with no definite line of demarkation.

Here in the Sphyrriidae also all the thorax segments take part in the elongation, but in females like the one represented in figure 68, on which portions of the swimming legs still persist, it can be seen that each pair is separated from the one preceding it by a distance which at first increases and then decreases as we proceed backward. This means that the third and fourth segments contribute more than the others to the elongation. Moreover, the position of the fourth legs at the anterior end of the trunk shows that the latter is really a fusion of the fourth, fifth, and sixth segments.

Torsion.—With reference to torsion the same may be said that has already been given in the case of the Lernaecidae.¹ In burrowing through the tissues of the host the head of the parasite does not always come in contact with the dorsal aorta, and the parasite has to burrow to the right or left in search of it, thereby producing a twisting of the body around its longitudinal axis. If the burrowing starts on the right side of the host, the head is more often turned to the left in search of the aorta; if on the left side, it is more often turned to the right; if on the median line behind the dorsal fin, it may be turned in either direction to get around the vertebral column. As a result we find varying degrees of direct or inverse torsion as in the Lernaecidae, and similar torsion must be found in any parasite

¹Proc. U. S. Nat. Mus., vol. 53, p. 10.

that thus searches by burrowing for some convenient source of its food supply. But we can not argue either that such genera belong to the Lernaeidae simply because they show torsion, or that the amount and direction of torsion is constant enough to furnish specific characters. Since the male never burrows but remains free upon the outside of the body of the host, or upon the body of the female, it never exhibits torsion.

Food.—As in the Lernaeidae, the simple fact that the females thus burrow through the tissues of the host until their mouth is brought in contact with some blood vessel is sufficient proof that the fish's blood constitutes their food. The male is provided with a well developed sucking proboscis and with the ordinary piercing mouth parts found in other male parasitic copepods. The body also contains digestive and excretory glands as well developed as those of the Lernaeopod males, and in addition the posterior portion of the digestive tract is fully developed, with an anus opening to the exterior. It seems reasonable, therefore, to assume that the male also feeds upon the blood of the host, at least until it takes a position on the body of the female. And even then, so deeply is the female buried in the tissues of its host, the male would not have far to crawl in order to reach the fish's skin.

Hosts.—The species of this family are confined entirely to salt water fishes, and further to deep-sea forms, or at least to those that live in the open ocean. The two species of the new genus *Paeon* and the single species of *Trypaphylum* are found in the gill cavity of sharks. The other species are found either in the gill cavity or on the outside surface of various deep-sea fishes ranging from the African cod to the common rat-tail off our North American coast.

Parasites.—All the specimens examined by the author except those of *Paeon versicolor* have proved to be remarkably clean and free from parasites or messmates, either animal or vegetable. In a single specimen of *Rebelula bouvieri*, taken from *Macrourus bairdii*, the part of the body which hung free outside the fish's skin was completely covered with a dense growth of algae.

EXTERNAL MORPHOLOGY.

The body of a Sphyriid is divided into three distinct regions—a cephalothorax made up of the head and first thorax segment, a long slender neck, chitinous and sometimes filose, and a trunk made up of a little of the posterior end of the fourth thorax segment, all of the fifth and sixth segments and the abdomen.

In *Opimia* the cephalothorax is smooth and destitute of processes or horns, in all the other genera it is profoundly modified by outgrowths and enlargements. These may take the form of soft processes or chitin horns. The soft processes are found on the front

and sides of the cephalothorax and may be small and more or less spherical in shape, or produced into immense foliaceous affairs, larger than all the rest of the body and themselves covered with secondary processes, simple or branched.

This condition occurs in the genus *Sphyrion*, but to interpret the secondary processes as modified legs (*pattes transformés*), as was done by Thor (1900, p. 280) and Quidor (1912, p. XLI), is manifestly out of the question. That would render it necessary for us to assume the fusion of the entire thorax with the head, which the breaks in the longitudinal musculature show to be impossible. These soft processes have thin walls and are filled with spongy chitinous tissue, which is continuous with that filling the cavity of the cephalothorax proper.

The horns are of narrow diameter and fully chitinized; they are found at the junction of the cephalothorax with the neck, and are developments of the latter, as is shown in the new genus *Periplexis*, where they are developed over a considerable portion of the anterior neck, and also in the genus *Rebelula*, where the entire neck is often covered with chitin knobs. They may be either simple or branched, the branching sometimes becoming very profuse, as in the new species, *Rebelula cornuta*.

In *Periplexis* and *Rebelula* the cephalothorax is an elongated cylinder, with all the soft processes at the anterior end, which is the true head. The remaining thoracic portion may be either smooth, as in most species of *Rebelula*, or transversely wrinkled, as in *Periplexis* and *Rebelula cornuta*.

This wrinkling, however, may be more or less the result of preservation.

The neck, with the exception of the modifications just noted, is usually smooth and of the same diameter throughout, but may be enlarged a little posteriorly (*Sphyrion*) or wrinkled where it joins the trunk (*Paeon*). Since these outgrowths of the head and neck are modifications which begin only after the female has burrowed into the tissues of the host, and which increase in complexity with subsequent growth in size, it is evident that they possess but little specific value. At all events two species of the same genus can not be satisfactorily established upon these characters alone, as has been attempted in the genus *Sphyrion*. If young females can be compared, differences in the position, arrangement and form of the outgrowths will have far more value than in older and more mature specimens. But even then the chief basis of differentiation must be the form and structure of the appendages. Because of the scarcity of the younger stages and because the adult female loses most of her distinguishing appendages, we must of necessity turn to the male for diagnostic characters.

The trunk is more or less enlarged and flattened dorso-ventrally; it is usually heart-shaped, the apex of the heart joining the neck, but it assumes an elongated club shape in *Opimia* and *Paeon ferax*. The surface is normally smooth and convex, but as a result of the contraction of the internal dorso-ventral muscles it may become pitted when those muscles are universally distributed, or may exhibit a few larger depressed areas, symmetrically arranged, when the muscles are gathered in bunches. The wall of the trunk is rather thin and so soft that in some species, such as *Paeon ferax*, it is easily pressed out of shape. In young females the posterior end has not yet assumed the typical heart shape, but is narrowed into a rounded lobe terminated by large anal laminae (see fig. 17). As growth progresses and the heart shape, with its median sinus and lateral lobes, is assumed the rounded lobe disappears and the anal laminae become flattened together and thickened until in the mature adult they form together a small hemispherical knob, nearer the dorsal than the ventral surface. On either side of the laminae and ventral to them is a genital knob, out of which opens the oviduct.

From the dorsal surface of the genital segment and the anal laminae arise a pair of posterior processes. These may develop into long, smooth, simple cylinders (*Opimia*, *Paeon*), or they may become lobed (*Periplexis*), or they may begin to branch and the branches may divide dichotomously until they assume a fancied resemblance to bunches of grapes (grappes de rasins) as in the genus *Sphyrion*, or each branch may grow into a long and narrow cylinder, in which event the whole process is likened to a tuft of hair (faisceau de poils) as in the genus *Rebelula*.

Here again, of course, the size and complexity of the final mass will depend largely upon the age of the specimen examined, and will be of practically no value in determining species.

The egg strings are straight and cylindrical and the eggs inside them are small and multiseriate, but are not arranged definitely in rows as in the Lernaeopodidae.

The appendages are the same as in the Lernaeidae, namely, two pairs of antennae, a pair of mandibles, two pairs of maxillae and a pair of maxillipeds. But these can only be seen in young females and males; some or all of them are wanting in the matured female adult.

The first antennae in the young *Sphyrion* female (fig. 18) are on the anterior surface of the head, dorsal to the mouth tube, and are minute in size and destitute of setae. The second pair are at the sides of the mouth tube; they have swollen basal joints and are tipped with the rudiments of a chela. The mouth tube is at the center of the antero-ventral margin of the head and is directed diagonally forward and downward. It is made up of a distinct labium and labrum, the

former of which is fringed at the tip, and the two are joined so as to leave an opening on either side. The mandibles are inside the tube and are stylet-shaped, their adjacent surfaces set with a row of fine teeth.

The first maxillae are on the outside of the tube; each is one-jointed and tipped with a tiny spine. The second maxillae are on the ventral surface of the head behind the mouth tube; each consists of a simple finger-like joint, projecting ventrally and tipped with a small claw.

The maxillipeds are considerably larger, and each consists of a basal joint fused with its mate across the midline and a free terminal joint tipped with a stout claw. As growth progresses and the various processes grow out upon the cephalothorax some of these appendages usually disappear, or they may be changed somewhat in position, so that in the mature adult they are hard to find. But careful search will usually reveal at least some of them. The swimming legs are very quickly broken off and are never found upon the adults of either sex. But on the same young female whose mouth parts are shown in figure 12 there were the remains of the first and fourth pairs. The first pair were on the cephalothorax and the fourth pair on the anterior end of the trunk. We can judge where the others must have been by the breaks in the longitudinal musculature.

INTERNAL MORPHOLOGY.

Body wall.—The body wall is similar to that of the Lernaeidae, being made up of two layers, an outside transparent layer, which in this family never becomes chitinous except in the neck and horns, and an inner opaque layer, made up of cells containing nuclei.

The outer layer is quite thin over the cephalothorax and trunk in *Paeon*, but is conspicuously thickened in the neck and at the posterior corners of the genital segment; in *Sphyrion* and *Rebelula* it is thick and leathery all over the body. It is made up of thin lamellae packed closely together without intervening spaces, and contains pore canals connected with the inner layer. The latter varies in thickness in different parts of the body, but nowhere attains anything like the depth found in some of the Lernaeidae. Nor does it anywhere form glands like those seen in *Sarcotretes* and other Lernaeids. But it does make up a spongy tissue which fills the cephalothoracic and posterior processes, as well as those portions of the cavity of the head and trunk not otherwise occupied. In bulk, therefore, it is by far the most extensive tissue in the body.

Muscular system of the female.—We know nothing of the musculature of the free swimming larva, but it must of necessity be more extensive and complicated than that of the adult. The youngest of the developmental stages of *Sphyrion* here mentioned shows the same muscles as the matured adult with one exception. There is in

this stage (fig. 30) a complex system of dilator muscles running forward and backward from the junction of the genital segment and abdomen to the sides of the barrel-shaped rectum. These indicate that the rectum takes an important part in respiration during early development. But although the rectum is retained in the matured adult and increases in size with the growth of the rest of the intestine, these dilator muscles do not increase accordingly. They become restricted to that part of the rectum contained in the abdomen, and when the latter is finally reduced almost to nothing these muscles are too weak to accomplish much.

There are no muscles connected with the first antennae in any female thus far examined, but the second antennae show a well developed musculature. The presence of corresponding muscles in two spherical processes on the head of *Rebelula* indicates that these processes are really the remains of the second antennae, because the other cephalothoracic processes do not possess muscles.

In *Paeon* there are very strong muscles connected with the second maxillae, while the musculature of the maxillipeds is weak and practically useless. In *Sphyrion*, on the contrary, the musculature of the second maxillae is comparatively weak, while that of the maxillipeds is much stronger, although relatively not as strong as in the maxillae of *Paeon*.

The muscles connected with the swimming legs of the larva entirely disappear in the adult.

The body muscles of the female are separated naturally into two sets, the longitudinal and the dorso-ventral muscles. The longitudinal muscles are very similar to those of the Lernaeopodidae, with certain minor variations. On the dorsal surface there are four bands of muscle, two on either side of the median line, running the entire length of the body from the base of the dorsal cephalothoracic processes to the anterior margin of the abdomen. In *Paeon ferox* and in *Sphyrion* and *Rebelula* the two inner bands are separated a little in the trunk, leaving an open space along the median line over the intestine. In *Paeon versicolor* they remain close together, but the two outer bands are removed nearly or quite to the lateral margin of the trunk.

On the ventral surface are four wide bands, two on either side, which run similarly from the base of the maxillipeds to the anterior margin of the abdomen. All four of these remain close together throughout their entire length in *Paeon versicolor* and in *Sphyrion* and *Rebelula*, but in *Paeon ferox* the two outer ones are removed to the lateral margins of the trunk. Consequently in *Paeon ferox* there are two median dorsal bands separated by a narrow interval, two median ventral bands and two bands on each lateral margin of the trunk. In *Paeon versicolor* there are two median dorsal bands, not

separated, two lateral dorsal bands, one on each side, and four median ventral bands. In the other genera there are four median dorsal bands, separated a little along the midline, and four median ventral bands.

In *Paeon* all these muscles show distinct breaks at the dividing lines between the body segments and enable us to determine what part each segment has taken in the body elongation. A similar break in the median dorsal muscles just before reaching the base of the anal laminae shows that an abdomen is really present, even though it be reduced almost to nothing and so thoroughly fused with the genital segment as to be otherwise indistinguishable. The posterior processes in the young *Sphyrion* (fig. 20) are manifestly attached to the abdomen. The base of the posterior processes in *Paeon* being posterior to the muscle break, they must also be regarded as abdominal.

The second set of muscles, which are dorso-ventral, have no counterpart in any of the other copepod families. They consist of individual muscle strands either scattered uniformly over the entire area between the intestine and the lateral walls of the trunk (*Paeon*, *Sphyrion*), or gathered into bundles in restricted areas (*Rebelula*, *Peripleuris*). When scattered the individual strands are not usually vertical, but are inclined a little in one direction or another. Between these strands are woven the coils of the oviducts and by their contraction the muscles undoubtedly aid the passage of the eggs along the oviducts. A simultaneous contraction of all the muscles produces a depression of the dorsal and ventral surfaces of the trunk over the area covered by the muscles. In the case of the restricted areas such contraction produces pits symmetrically arranged and corresponding in position on the dorsal and ventral surfaces. There are the usual muscles connected with the vulvae and assisting in the extrusion of the eggs into the egg strings.

Muscular system of the male.—The musculature of the male is well shown in figure 59, which is a side view of the male of *Paeon ferox*. The muscles of the cephalothorax are connected entirely with the antennae and mouth parts, and every appendage except the first maxillae is well supplied. The muscles of the second maxillae and maxillipeds are especially numerous and powerful and must make of those appendages very efficient prehensile organs. In the thorax there are simply the usual muscles between the segments on the dorsal and ventral surfaces, which produce flexion and extension. In the fused posterior portion, or trunk, there is in addition a strong diagonal muscle on either side which aids in extruding the spermatophores.

Alimentary canal.—The mouth opens into a short esophagus, which is usually inclined dorsally and fairly straight, but in *Rebe-*

lula it takes on more or less of an S curve. It opens into the stomach at the anteroventral margin of the latter, the opening being surrounded by a rather weak sphincter muscle. The mouth tube is not sufficiently protrusible in any species of this family to affect the esophagus at all. The stomach is abruptly enlarged behind the sphincter and shows neither convolutions or processes in any of the species examined. It is lined with digestive epithelium similar in all respects to that found in other families. It passes insensibly into the intestine which is rapidly narrowed into a mere thread on entering the neck, and which shows neither convolutions nor foldings. The intestine is widened again on emerging from the neck, passes nearer to the dorsal surface of the trunk, and is contracted again into a relatively large and barrel-shaped rectum. The latter evidently functions as an effective organ of respiration in developmental stages, and is operated by a set of dilator muscles on either side. But after the development of the posterior processes this function is shifted to them, and although the rectum persists and increases in size, it simply serves for the expulsion of the excreta.

The intestine is smooth and unmodified in *Paeon*, but in *Sphyrion* and *Rebelula* it becomes remarkably changed by the development of lateral and dorsal processes. The wall of the intestine bulges out in two rows of small knobs along either side, one dorsal and one ventral, and one row along the center of the dorsal surface (fig. 30). These knobs gradually elongate until the ends of those in the three dorsal rows reach the dorsal wall of the trunk, against whose inner surface they flatten out (fig. 31). The two ventrolateral rows grow laterally more than ventrally, until they reach and flatten out against the dorsoventral muscle strands.

The inner cavity of all the processes remains in full communication with the lumen of the intestine. The dorsolateral processes reach the dorsal wall of the trunk just inside of the dorsoventral muscles, while the dorsocentral processes flatten out between the longitudinal bands of muscle.

Subsequently in *Sphyrion* all the processes elongate laterally until on the dorsal surface they fill almost the entire median space between the two sets of dorsoventral muscles, with only a very narrow sinus on either side beneath the longitudinal muscles and between the central and the lateral row. On the ventral side they crowd out into the dorsoventral muscles and grow inward around the intestine, until they almost meet on the midline, presenting the appearance seen in figure 32.

The intestine, together with these five rows of processes, fills practically all the lumen of the trunk between the dorsoventral muscles, the only vacant space being below the center of the intestine, be-

tween the ventral rows of processes. All the processes are shorter and smaller anteriorly and posteriorly, and wider and larger along the center; they stop posteriorly at the contraction between the intestine and the rectum, and anteriorly at an equal distance from the anterior end of the trunk.

In *Rebelula* the system of processes begins at the junction of the neck and trunk and ends just behind the longitudinal center of the trunk. In this genus the anterior processes grow much more rapidly than the posterior and branch profusely. They thus come to fill the entire lumen of the trunk from wall to wall for about one-fourth of its length, the ends of the branches flattening against the inner surface of the wall on all sides. They then diminish rapidly laterally but still reach the dorsal and ventral body wall. The combined mass assumes something of a triangular outline, widest anteriorly and narrowing to a point posteriorly.

The branching of the processes destroys the appearance of being in rows, and makes the mass look far more like a bunch of grapes than is the case with the posterior processes of *Sphyrion*. Cornalia discovered this mass of processes in his "*Lophoura edwardsii*," but mistaking the nature of the intestine he called them blind appendages of the stomach.

He only represented them along the anterior margin, however, and did not see that they extended as well over the entire surface of the anterior trunk.

NERVOUS SYSTEM.

We know nothing about the nervous system in any of the larval stages, but in the matured adult it is practically the same as in the Lernaedae. There is, however, one important difference. In every Lernaean genus the tripartite eye of the larva persists in the adult, buried deeply in the tissues over the base of the esophagus, but still easily recognized in cleared specimens. In the present family the eye is entirely lacking and there is no trace of it in any genus. The remains of the two esophageal ganglia can still be seen in sections and the beginning of the ventral nerve cord. But no nerves can be found in the neck or trunk either in sections or in cleared specimens. Such nerves must exist, however, to control the various trunk muscles, especially those connected with the passage of the eggs along the oviducts and their extrusion into the external egg sacks.

REPRODUCTIVE SYSTEM.

Male reproductive organs.—These consist of a pair of testes situated in the posterior part of the head, a pair of nearly straight *vasa deferentia*, each surrounded for a portion of its length by a cement gland, and a pair of spermatophore receptacles. The testes are dorsal

to the stomach and intestine, and are so large in *Rebelula* that they cause the posterior portion of the head to bulge out dorsally into two hemispherical knobs. The *vasa deferentia* are given off from the posterior ends of the testes and run back nearly in a straight line along either side of the body to the dorsal portion of the genital segment, where they turn down ventrally and are enlarged into spermatophore receptacles. For a considerable portion of its passage along the side of the body each *vas deferens* is surrounded by a mass of glandular tissue which secretes and pours into the lumen of the sperm duct the cement substance, which hardens into the covering of the spermatophore. The opening through which the spermatophore is extruded is on the ventral surface, just in front of the posterior processes.

Female reproductive organs.—The ovaries are paired, and are situated either along the lateral margin of the anterior portion of the trunk (*Sphyrion*), or just inside and in front of the cement glands (*Paeon*, *Rebelula*). They are nearer the dorsal than the ventral surface, and are slightly flattened against the lateral wall. Each ovary consists of a mass of tiny cells, with no arrangement into filaments, but with all the eggs separate and in close contact one with another. But there is not the uniform gradation in size from one end of the ovary to the other that was found in the Lernaeidae. The eggs increase rapidly in size as soon as they leave the ovary through the absorption of food material and yolk. They are arranged in the oviduct in a single row, and retain perfectly their spherical shape. Occasionally they become flattened a little through crowding, especially around the turns of the oviduct, but they are never compressed into disks.

The oviducts are narrow and thread-like and are coiled back and forth laterally between the dorsoventral muscle strands without any definite arrangement. Apparently they first fill the space at the posterior portion of the genital segment between the cement glands and the intestine, and then extend forward into the central portion of the trunk which represents the fifth thoracic segment, and may even reach in *Paeon* and *Sphyrion* the extreme anterior end of the trunk, the fourth thorax segment.

In *Rebelula* they are prevented from doing this by the branched intestinal processes and occupy only the triangular space on either side behind those processes. The sperm receptacle is situated at the posterior end of the genital segment, on the median line between the two vulvae, and ventral to the intestine. The cement glands are in the postero-lateral portions of the genital segment and follow the contour of the body wall. The glandular portion is long and narrow except in *Paeon versicolor*, where it is short and thick. It lies a little nearer the ventral surface and is usually curved inward a

little at the extreme anterior end. The whole gland is also concave inwardly, the two assuming the form of parenthesis marks. The glandular portion does not show segmentation in any genus, but in preservatives the cement substance through the center of the gland usually breaks up into thin disk-like laminae, arranged like a row of coins. The duct is short and filose and enters the oviduct just inside the vulva. The external egg sacks are long and straight, usually uniform in diameter, or only slightly narrowed posteriorly and bluntly rounded at the end. The eggs are packed into them rather loosely and without any definite arrangement in rows.

And of course the developing larvae are not arranged in any definite relation to the outer walls of the sack. The eggs are very numerous in all the genera but especially so in *Rebelula*, where the number often reaches into the thousands. Nothing is known of the shape or size of the spermatophores since none were present in any of the females thus far examined.

SYSTEMATIC PART.

SPHYRIIDAE, new family.

External family characters of female.—Body divided into three distinct regions, a soft cephalothorax, a slender neck, chitinous and armed with processes or horns at its junction with the cephalothorax except in *Opimia*, and a trunk, flattened dorsoventrally and usually with pits or depressions on its dorsal and ventral surfaces. Abdomen minute and thoroughly fused with the genital segment in young females, much reduced or practically lacking in the adult, but the anal laminae always present. One pair of posterior processes; egg strings long and cylindrical, eggs multiseriate.

Two pairs of antennae in young stages, second pair chelate; a more or less protrusible proboscis; two pairs of maxillae, second pair uncinatate; one pair of maxillipeds also uncinatate.

Internal family characters of female.—Body cavity extending into the processes of the cephalothorax and the posterior processes of the abdomen. Digestive tube extending through the center of the body, nearer the dorsal surface in the trunk, without convolutions but profusely covered with processes in *Sphyrion* and *Rebelula*. Ovaries paired, situated close to the lateral walls of the trunk; oviducts profusely coiled, coils separated by dorsoventral strands of muscle either universally distributed or gathered in bunches; cement glands at the posterior corners of the genital segment, usually without joints. Chitinogen layer well developed, especially at the posterior corners of the genital segment, in the cephalothoracic and posterior processes, and in the respiratory cylinders.

External family characters of male.—Body folded upon itself and unsegmented in *Sphyrion*, straight or curved and more or less segmented in the other genera; made up of two regions, a cephalothorax, bearing the antennae and mouth parts, and a thorax destitute of appendages. Two pairs of antennae, second pair chelate; proboscis long and retractile like those of the Lernaeopodinae. First maxillae biramose, second pair one-jointed, uncinat; maxillipeds with fused basal joints, terminal joints free, uncinat.

Internal family characters of male.—Digestive tube extending straight through the body, nearer the ventral surface. Testes paired in the posterior dorsal portion of the cephalothorax, often protruding strongly as spherical swellings; sperm ducts lateral, not convoluted but surrounded by large cement glands; spermatophore receptacles in the genital segment. A large frontal gland above the anterior end of the stomach; a large fused maxillipedal gland in the basal joints of the maxillipeds; smaller glands in the first and third thorax segments and near the anus.

Remarks.—This family is at once distinguished from the Lernaeidae by the presence of adult pigmy males attached to the females, while in the Lernaeidae the males do not pass beyond the fourth copepodid stage and are never found with the adult females. The Sphyrriidae also differ in the position and arrangement of the reproductive organs and in the presence of dorsoventral muscles, separating the convolutions of the oviducts and forming by their contraction pits or grooves on the dorsal and ventral surfaces of the trunk. Still another difference is found in the complicated system of processes attached to the intestine in the trunk of *Sphyrion* and *Rebelula*, which has no counterpart in the Lernaeidae.

In the elongation of the body of the female previous to and during burrowing all the thoracic segments take a part, the third and fourth segments being elongated the most. The trunk is composed of a part of the fourth and all of the fifth and sixth segments while in the Lernaeidae this is true only of the genus *Lernaea* (*Lernaeocera*). And in that genus the arrangement and position of the reproductive organs is like that of the other Lernaeans and radically different from the present family.

The males of the Sphyrriidae closely resemble those of the Lernaeopodidae, particularly the genera *Achtheres*, *Salmincola*, *Lernaeopoda*, and *Clavellisa*, but the females bear no resemblance whatever, lacking the peculiar second maxillae, having lateral processes or horns on the cephalothorax, and burying the head and neck in the tissues of the host.

From the Chondracanthidae, with which family some of the present genera have at times been placed, the females differ in the absence of prehensile second antennae and thoracic legs and in the presence of

lateral processes on the cephalothorax, in the long slender neck, and in the posterior processes on the abdomen. The males differ in the entire absence of swimming legs, in the fusion of the basal joints of the maxillipeds, and in the structure of the antennae and mouth parts. The family is thus clearly differentiated from all the other copepod families and occupies a place peculiarly its own, its males closely resembling those of the Lernaeopodidae and its females bearing some external resemblance to those of the Lernaeidae.

ARTIFICIAL KEY TO THE GENERA.

1. Posterior processes cylindrical, smooth, and divided into large lobes; neck bent and twisted and armed with numerous chitin horns.

Periplexis, new genus, p. 598.

1. Posterior processes cylindrical, smooth, neither lobed nor divided; neck straight and smooth, no chitin horns.----- 2.

1. Posterior processes covered with gill cones or cylinders; neck straight and smooth, with horns or processes.----- 3.

2. Cephalothorax orbicular, without processes; neck stout and flattened.

Opimia Wilson, 1908, p. 589.

2. Cephalothorax transversely ellipsoidal, with three pairs of prominent processes; neck slender and cylindrical.-----*Paeon*, new genus, p. 590.

2. Cephalothorax orbicular, furnished with cartilaginous horns; neck slender and cylindrical.-----*Trypaphylum* Richiardi, 1878, p. 588.

3. Cephalothorax a narrow cylinder, with small lateral processes or horns; neck filose.-----*Rebelula* Poche, 1905, p. 576.

3. Cephalothorax short and very wide, much flattened, with enormous lateral processes, often lobed; neck thick and stout.---*Sphyrion* Cuvier, 1839, p. 566.

Genus SPHYRION Cuvier.

Chondracanthus QUOY and GAIMARD, Freycinet's Voyage autour du Monde, 1824, Zoologie, Atlas, pl. 86, fig. 10. "Chondracanthe lisse."

Sphyrion CUVIER, Le Règne Animal, 1830, vol. 3, p. 257. "Sphyrion lisse."

Sphyrion GUÉRIN-MENEVILLE, Iconographie du Règne Animal, 1829-1843, vol. 2, p. 11, pl. 9, fig. 4. *Sphyrion laevigatus*.

Sphyrion MILNE EDWARDS, Histoire Naturelle des Crustacés, 1840, vol. 3, p. 525.

Lestes KRØYER, Danmarks Fiske, 1845, vol. 2, p. 517.

Sphyrion STEENSTRUP and LÜTKEN, Kong. Danske Videns. Selskab. Skrifter, 1861, ser. 5, vol. 5, pp. 347 and 432.

Lesteira KRØYER, Naturhistorisk Tidsskrift, 1863, ser. 3, vol. 2, p. 402.

Lesteira HELLER, Reise der *Novara*, 1865, Crustacea, p. 228.

Lesteira G. M. THOMSON, Trans. New Zealand Inst., 1890, vol. 22, p. 370.

Sphyrion BASSETT-SMITH, Proc. Zool. Soc. London, 1899, pp. 441 and 488.

Sphyrion STEBBING, Cape of Good Hope, Dept. Agric., South African Crustacea, *Sphyrion laevigatum*, p. 60, pl. 4, 1900.

Sphyrion THOR, Ann. Sci. Nat., ser. 8, 1900, vol. 11, p. 277. *Sphyrion australicus*, new species, p. 280.

Sphyrion QUIDOR, Archiv. Zool. expér. et gen., ser. 5, 1912, vol. 10, p. xxxix,

Sphyrion delageti, new species, p. xii; *stewarti*, new species, p. xiii.

Sphyrion T. and A. SCOTT, British Parasitic Copepoda, 1913, vol. 1, p. 164.

External generic characters of female.—Cephalothorax transversely expanded into a pair of enormous soft processes of varying

shape, forming the sphyra or hammer, from the center of whose anterior surface projects the head. Neck smooth, of medium diameter and often enlarged posteriorly. Trunk greatly enlarged transversely, flattened dorsoventrally, smooth or pitted according to the contraction of the dorsoventral muscles; no abdomen but a pair of knob-like anal laminae. A pair of posterior processes profusely and dichotomously branched; egg strings long and straight; eggs multi-seriate. In young females two pairs of antennae, two pairs of maxillae, one pair of maxillipeds, no swimming legs. In older females the appendages degenerate into knobs or entirely disappear.

Internal generic characters of female.—Mouth tube at the extreme anterior margin of the head, inclined ventrally; esophagus entering the stomach on the anteroventral surface; stomach without lateral processes; intestine narrowed in the neck and widened in the trunk, where it develops a complicated system of processes; rectum short, opening between the anal laminae; cement glands strongly curved, close to the posterolateral walls of the genital segment, indistinctly jointed; ovaries close to the body wall on either side and reaching from the anterior end of the trunk to the anterior end of the cement glands; oviducts profusely coiled, the convolutions separated by strands of dorsoventral muscles; chitinogen layer thickest in the anterior part of the trunk, outside of the oviduct coils.

External generic characters of male.—General form an elongated ellipsoid, with the cephalothorax attached to one end on a level with the dorsal surface and covered with a minute carapace. Body folded upon itself very much as in the Lernaeopod genus *Clavellisa* and thoroughly fused, without distinction of parts or segmentation; mouth tube, appendages, and a genital process on the ventral surface. Two pairs of antennae on the anterior margin of the tiny carapace; two pairs of maxillae; maxillipeds slender and chelate, their basal joints fused.

Internal generic characters of male.—Esophagus not much inclined to the body axis, but quite long and entering the stomach at the anterior end. Stomach close to the dorsal surface of the head, passing insensibly into the intestine which follows around the curve of the body, and then turns forward and opens at the anus just behind the maxillipeds. Testes paired, between the stomach-intestine and the dorsal wall of the head, opposite the bases of the maxillipeds; sperm duct coiled backward and forward twice between the intestine and the lateral body wall, the last time forming a fairly large spermatophore receptacle.

Type of the genus.—*Sphyrion laevigatum* Guérin Meneville. (*Sphyrion*, σφύριον, a little hammer.)

ARTIFICIAL KEY TO THE SPECIES.

Cephalothorax (hammer) only half wider than long and smooth; neck without processes, longer than the rest of the body combined; genital segment longer than wide-----*lumpi* (Krøyer), 1837, p. 570.

Cephalothorax (hammer) two or three times as wide as long and covered with soft processes, often branched; neck shorter than genital segment; the latter wider than long-----*laevigatum* Guérin-Meneville, 1839, p. 575.

Remarks.—From the series of developmental stages here presented it can be easily seen that the body dimensions will vary greatly with the growth. The hammer tends to become more and more elongated transversely; its surface remains smooth and unbroken in *lumpi*, while in *laevigatum* it becomes broken into numerous processes and warts. Once this latter sort of growth is begun it is manifest that there will be no limit either in the number or the pattern of the excrescences. The antennae and mouth parts alone will show any regularity of position, size, or shape.

Furthermore the same individual will show a very different pattern of cephalothorax at different stages in its growth. And probably no two individuals of the same species will ever be just alike.

The neck varies greatly in length, in actual diameter, and in relative diameter at its anterior and posterior ends. In general, the older and the larger the parasite becomes, the smaller is the neck diameter in comparison with the other body regions. The trunk changes the least of any part of the body, but even it must become considerably swollen with the maturation of the eggs and shrunken after their extrusion into the external sacks. On the other hand, there is the greatest chance for variation in the posterior processes. They start as simple branches at the point of fusion of the anal laminae with the genital segment, and become more and more complexly branched with growth. As in shrubs and trees, therefore, we must not expect to find exact duplicates of any particular pattern, but only a general similarity in the mode of branching.

In the same way we might well find the tips of the branches swollen into spheres in one specimen, normally cylindrical in another, and flattened in a third. Such considerations as these make any differentiation of species upon the external characters of the female alone very questionable. The best, and probably the only reliable, method of separating species will be by comparison of the males and young females whose mouth parts have not yet become degenerate.

Seven species of the genus have been thus far proposed, but a careful comparison of the descriptions given, which are based entirely upon the external appearance of the female, apparently reduces the species to the two given above. Since most of the descriptions place

considerable emphasis upon size, a table of the comparative sizes of the seven species is here given. The figures are millimeters.

Species.	Hammer.		Neck.		Trunk.		Egg strings.	
	Length.	Width.	Length.	Width.	Length.	Width.	Length.	Width.
<i>lumpi</i>	13-16	10	15-35	2.5	12-16	12	20	2.5
<i>laevigatum</i>	15-60	4-20	7-12	1-3.5	9-20	9-28	26	2
<i>australicus</i>	20	2-8	7	1-2	10-12	15	30	2.5
<i>delagei</i>	25	11	7	1-2	9	15	20	2.5
<i>stewarti</i>			10	5	12	14	30	2
<i>kingi</i>	21	7	4	1.5	14	17	37	2
<i>krøyeri</i>	54	10	12	1-3.5	11	18	25	2

The length of the hammer is transverse to the body axis.

The first two species in the table are conceded to be distinct, and it will be noted that the variations given for the second species, *laevigatum*, are amply sufficient in range to cover the five following species, but it will be interesting to note these species in detail.

SPHYRION AUSTRALICUS Thor.

This species has a more robust structure than *laevigatum*, the egg strings are a little longer, and the hammer has long digitiform processes which Thor regarded as transformed legs. The neck is strongly curved and twisted until the hammer is at right angles to the trunk. The posterior processes are the same size and shape as in *laevigatum* but are perhaps a little less branched. This parasite was reported to have been taken from "la grande morue rouge d'Australie" although there is no cod known from Australia that is large and red.

Obviously there is not enough in this description to render the species valid and it must be considered a synonym of *laevigatum*.

SPHYRION DELAGEI Quider.

The hammer is longer and narrower than in *australicus*, and the protuberances which it carries are smaller. The neck and trunk are bent to the left and the neck shows a direct torsion of 90°. The processes of the hammer are more or less regular and probably represent modified appendages. The trunk has the form of an ellipse, much wider than long; the abdomen is reduced and carries on its ventral surface two bunches of chitin appendages, whose branching is analogous to that in *australicus*, but whose tips are spherical instead of being flattened. The species is based on a single specimen taken from behind the dorsal fin of a cod in the Sandwich Islands. Here again there is nothing to constitute a specific difference and the species must be regarded as a synonym of *laevigatum*.

SPHYRION STEWARTI Quidor.

The hammer is entirely lacking and the host is unknown, but the single specimen came from New Zealand. That part of the neck which remains is considerably wider than in any other reported specimen; the trunk is quadrangular and flattened, and the abdomen is distinctly visible. The posterior processes are branched dichotomously and the branches are perpendicular to the surface of the bunch, and their swollen tips are the only things visible. Such slight differences are hardly enough to constitute a valid species based on a single mutilated specimen.

SPHYRION KINGI Cunningham.

In his Notes on the Crustacea obtained during the voyage of H.M.S. *Nassau* Cunningham¹ published this new species. He gave no description, but merely said that it differed from *laevigatum* "in the greater width of the sucking disk (hammer) and of the body, as well as in various other points which will be readily understood by a comparison of the figures of *laevigatum* and *kingi*." The figure he gave, however, showed no details save those of the relative shape and size of different parts of the body, and they are not enough to establish his species.

SPHYRION KR YERI (Thomson).

Thomson referred this species to Krøyer's genus *Lesteira*; it differs from other species chiefly in the shape of the hammer, whose transverse diameter is greater than the entire length of the body. The neck and trunk are hard and horny, and the bunches of posterior appendages are as long as the trunk itself. Taken from the abdomen of a ling, *Genypterus blacodes*, near New Zealand. Here again the species rests for its validity almost entirely upon the shape of the hammer, and can not be accepted without further proof.

SPHYRION LUMPI (Krøyer).

Plates 50, 51, and 52.

Lestes lumpi KRØYER, Danmarks Fiske, vol. 2, 1845, p. 517.

Lesteira lumpi KRØYER, Naturhist. Tidsskift, ser. 3, vol. 2, p. 325, pl. 18, fig. 5, 1863.

Lesteira lumpi STEENSTRUP, Overs. Kongel. Danske Vidensk. Selsk. Forhandl., 1869, no. 3, p. 182, pl. 2, figs. 4 and 5.

Sphyrion lumpi BASSETT-SMITH, Proc. Zool. Soc. London, 1899, p. 489.

Sphyrion lumpi T. and A. SCOTT, British Parasitic Copepoda, 1913, p. 164, pl. 51, figs. 3 and 4.

Host and record of specimens.—The United States National Museum contains the following specimens: A single female (Cat. No. 42342, U.S.N.M.), from a salted hake; a single female (Cat. No.

¹ In Trans. Linn. Soc. London, vol. 27, 1871, p. 501.

49759, U.S.N.M.), from *Sebastes marinus* taken off Cape Cod in 1879; a single female with attached male (Cat. No. 49760, U.S.N.M.), from *Nematonurus goodei* taken off the New Jersey coast by the *Albatross* in 1884; four immature females (Cat. No. 49761, U.S.N.M.), from the same host and locality in 1885; a single female, lacking the hammer, from *Haloporphyrus viola*, cleared to show the internal anatomy.

Specific characters of female.—Cephalothorax enlarged by lateral processes until it is usually a little wider than the genital segment. In young females and in some mature ones the outer ends of the processes are bluntly pointed, giving the hammer a transversely elliptical outline, with rather pointed ends. In other specimens the ends of the processes are enlarged into knobs and one or both of the knobs may be bifid, giving the creature much more of a hammer shape. Owing to torsion the transverse diameter of the head in matured females is usually at right angles to that of the trunk. Krøyer, who founded the species, claimed that this enlarged portion was the head alone, but most of the other observers have called it a cephalothorax, which it is now definitely proved to be by the presence of swimming legs in immature specimens. This cephalothorax is followed by a narrow neck of varying length, but fully as long in the young females as in the older ones. Then comes an enlarged trunk made up chiefly of the genital segment, which is more or less heart-shaped and strongly flattened dorsoventrally. To it are attached a pair of anal laminae and a pair of posterior processes, simple at first but becoming more and more profusely branched as the animal matures.

In the youngest specimen obtained (fig. 15.) the lateral lobes of the cephalothorax are small, not pointed, and plainly thoracic in origin; the head projects from the ventral surface and is scarcely visible in dorsal view. The walls of the entire body are of equal thickness and perfectly transparent like glass; the neck is very slender but is 25 mm. in length and of uniform width; the trunk is an elongated oval, five times the diameter of the neck; the abdomen is fused with the genital segment, but is well differentiated by breaks in the musculature and by lateral sinuses at its base; the posterior processes arise from its dorsal surface and are simple and unbranched, but somewhat flattened dorsoventrally.

Inside of the trunk the filiform intestine increases gradually in diameter and is then contracted again into a barrel-shaped rectum about one-fourth the distance from the posterior end. Along the enlarged portion can be seen the beginnings of the intestinal processes, which assume the form of two rows of small knobs on either side, one dorsal and the other ventral, and a single row along the center of the dorsal surface.

The cement glands and ovaries may be distinguished near the lateral walls of the trunk, but as yet they are only partially developed.

In an older specimen (fig. 18) the lateral processes of the cephalothorax are more pointed and relatively larger, the head has moved to the anterior margin and is plainly visible dorsally as well as ventrally; the neck and trunk have enlarged relatively in diameter and the posterior processes have elongated considerably, are much twisted, and have begun to branch. This specimen shows the antennae and mouth parts admirably, and it will be well to describe them in detail. The first antennae are three-jointed processes projecting from the anterior margin of the head near the center, just above and inside of the second pair. The basal joint is much the largest and the terminal joint is a minute knob on the tip of the second joint near its inner margin; these antennae are destitute of spines or setae. The second antennae are three-jointed, the basal joint much the largest; they start from the anterolateral corners of the head and curve diagonally inward and backward across the face, almost meeting on the midline. On the tip of the terminal joint are two processes arranged like a chela, one dorsal and the other ventral and a little lateral. Between these antennae lies the mouth tube which is conical and inclined forward and downward. On either side of the tube is a short process or knob, the first maxilla, tipped with a tiny spine. Posterior to the tube is the second pair of maxillae, each of which is a one-jointed, fingerlike process, with a small claw on its tip.

A short distance behind these is a pair of large fleshy processes, which stand out prominently from the ventral surface of the head; their adjacent surfaces are flattened together and fused on the midline so that the two form a hemisphere whose posterior surface, away from the mouth, is divided by a shallow median groove. On this posterior surface at the bases of the processes, where they easily escape notice, is a pair of one-jointed maxillipeds. Each consists of a swollen joint, pointed at the tip and armed with a stout and strongly curved claw and a long spine on the inner margin (fig. 10). These are so overshadowed by the large padlike processes in front of them that they can not be of any service to the matured female, but they probably assist it in securing its first hold upon its host, and in boring its way through the skin into the underlying tissues. A short distance behind the maxillipeds are the bases of the first swimming legs as is shown by the usual chitin ridge on the surface and by muscles beneath the skin. The legs themselves are broken off, but Rathbun obtained one of them and has given an excellent drawing of it. The basal joint is ovate and at the tip are two minute one-jointed rami, without spines or setae. There was a second pair of legs opposite the posterior margin of the lateral processes, but no traces of any others.

Inside the trunk (Fig. 31) considerable development has taken place; the five rows of intestinal processes are now very much in evidence and fill a large portion of the body cavity. Each of the lateral rows extends out obliquely from the surface of the intestine; the dorsal ones reach the dorsal body wall about halfway between the midline and the lateral margin, just inside the dorsoventral muscles, but the ventral ones do not reach the ventral wall. Instead they are more nearly horizontal and extend against the sides of the muscles, in some cases pushing a short distance between them. The dorsal row extend vertically upward and reach the dorsal wall of the trunk along the midline. There are thus two narrow spaces between the rows dorsally and a wide ventral space that is partially filled with spongy chitinogen tissue. The intestine still presents its general outline and all the processes stop before reaching the rectum. The ovaries and cement glands have also developed considerably and are plainly visible along the lateral margins, with quite an interval between them at the center.

The color of immature specimens is snowy white, becoming brownish as the female matures, and this brown is much deepened in preservatives. Measurements are given of two adults since they differ in details; the first figures given belong to the specimen shown in figure 1, the second to the specimen whose head is shown in figure 13, and which evidently resembled one of Krøyer's figures.

Total length, including posterior processes, 60–45 mm. Length of cephalothorax, 10–10 mm.; width 13–16.50 mm. Length of neck, 35–15 mm. Length of trunk, 16–12 mm.; width, 10–15 mm.; thickness, 6–5 mm. Length of posterior processes, 8–16 mm. Length of egg strings, 20–20 mm. The second specimen thus has a wider cephalothorax, a shorter neck, a shorter but wider trunk, and longer posterior processes.

As the females mature all the body regions thicken and the posterior processes become more and more profusely branched. A third stage of the latter is shown in figure 7, and the matured female is seen in figures 1 and 2.

From the above measurements it will be seen that one of the adults had processes fully twice the size of those on the other specimen. The internal anatomy of the matured trunk is shown in ventral view in figure 32. The intestine is considerably increased in diameter, and is nearer the dorsal surface of the trunk. On either side of it lies the long ventral row of processes, reaching nearly the whole length of the trunk and narrowed at either end. Here and there, especially toward the posterior end, a process is found which does not reach the whole width of the row, and then the adjacent processes on either side of it come together for the remainder of the distance. The processes have also grown inward over the ventral surface of the intestine and down-

ward until they reach the ventral body wall. Dorsal to the intestine the processes have also widened, but there is still a space on either side between the rows.

The ovaries now reach back to the anterior ends of the cement glands, and the oviducts are apparently given off from their posterior ends. These oviducts are coiled to the right and left in the space between the ovary (anteriorly) and the cement glands (posteriorly), and the intestinal processes on either side, and the coils are separated by strands of dorsoventral muscles, whose contraction helps to pass the eggs along the oviducts. The eggs are separate, and although in places they are close enough together to become somewhat flattened, they are never crowded. They finally issue into the external sacks at the posterior end of the genital segment, close to the median line. The cement glands are at the extreme posterolateral margin of the trunk, close to the body wall. They are long and slender and curved into the form of a parenthesis mark; they do not show regular segmentation; the ducts from these glands are short and threadlike and enter the oviduct just inside the vulva.

Specific characters of male.—In addition to the generic characters already given we may add that the basal joint of the first antennae is much the largest, the second and third joints are about the same size, and the terminal joint is tipped with two stout spines. The basal joint of the second antennae is twice as wide as long and unarmed, the second joint is the same width and length as the basal one, with a short spine at the outer anterior corner and on the inner margin a wide process armed with three stout spines; terminal joint half the width and length of the second joint and tipped with three stout spines. Second maxillae, two-jointed, joints stout and swollen, the basal one the larger, the terminal one tipped with a strong, bluntly pointed claw, bent into a half circle; on the inner margin of the joint near the tip is a short and stout spine. Basal joints of the maxillipeds fused across the midline; terminal joints rather slender and tipped with a chela, a strong claw on the anterior corner shutting down into a sheath on the opposite margin.

Color (preserved material) a uniform yellowish white. Total length, 2 mm.; width, 1 mm.; greatest thickness, 0.50 mm.

(*lumpi*, the specific name of the original host).

Newly hatched larva.—The present author has never seen the larva, but Krøyer gave two figures¹ which he designated "Pullus ex ovo productus," and which show several interesting features. The dorsal view looks somewhat like a nauplius, but lacks the balancers at the posterior end of the body; the side view shows unmistakably that it is not a nauplius, but a much more advanced larva. The first

¹ Naturhistorisk Tidsskrift, ser. 3, vol. 2, pl. 18, fig. 5, *f* and *g*.

antennae are distinctly three-jointed, and in addition to the other two pairs of nauplius appendages there are three pairs of mouth parts, two pairs of swimming legs, and the rudiments of an abdomen. This shows at least that the larva does not issue from the egg as a nauplius, like the Lernaeidae, but that it passes the nauplius and metanauplius stages inside the egg and comes forth in one of the copepodid stages like the Lernaeopodidae. Such a larval development separates the present family so much the more distinctly from the Lernaeidae.

Remarks.—Some doubt has been expressed by Stebbing and others whether Krøyer's species was distinct from *laevigatum*. The finding of the male and the appendages of the female, with the details here given, will serve to strengthen its validity. The female may be recognized by the prominent head projecting from the anterior margin of the cephalothorax by the general shape of the latter, and by the details of the appendages.

SPHYRION LAEVIGATUM Guérin-Meneville.

Chondracanthus lisse QUOY and GAIMARD, Freycinet's Voyage, 1824. Zoologie, Atlas, pl. 86, fig. 10.

Sphyrion lisse CUVIER, Le Règne Animal, 1830, vol. 3, p. 257.

Sphyrion laevigatus GUÉRIN-MENEVILLE, Iconographie Zoophytes, p. 11, pl. 9, fig. 4.—MILNE EDWARDS, Histoire Naturelle des Crustacés, 1840, vol. 3, p. 526.—CUVIER, Le Règne Animal, édition illustrée, Zoophytes, p. 62–63, pl. 32, figs. 4 and 4a.

Sphyrion laevis STEENSTRUP, Oversigt Vidensk. Selsk. Kjöbenhavn, 1869, p. 202, pl. 2, figs. 4a and 4b.—THOR, Ann. Sci. Nat., 1900, ser. 8, vol. 11, p. 278, pl. 17, figs. 1, 2, 4, 7–9; pl. 18, figs. 3, 5, 6, 14.

Lestira krøyeri THOMPSON, Trans. New Zealand Inst., 1890, vol. 22, p. 370, pl. 28, figs. 4 and 4a.

Sphyrion laevigatum STEBBING, Cape of Good Hope, Dept. Agriculture, 1900, p. 60, pl. 4.—QUIDOR, Archiv. Zool. expér. et gen., 1912, ser. 5, vol. 10, p. xl, 1 text fig.—BRIAN, Bull. Inst. Oceanog., 1917, no. 324, p. 3, 2 text figs.

Sphyrion australicus (?) THOR, Ann. Sci. Nat., ser. 8, vol. 11, 1900, p. 280.

Sphyrion delageti (?) QUIDOR, Archiv. Zool. expér. et gen., 1912, ser. 5, vol. 10, p. xli.

Sphyrion stewarti (?) QUIDOR, Archiv. Zool. expér. et gen., 1912, ser. 5, vol. 10, p. xlii.

Sphyrion kingi (?) CUNNINGHAM, Trans. Linn. Soc. London, vol. 27, 1871, p. 501.

The following description is adapted from Thor, 1900, cited above. The cephalothorax (hammer) is 14–15 mm. long (transversely), 4–6 mm. wide, and 3–4 mm. thick. On the ventral surface at the anterior margin are two large recurved processes, which Krøyer interpreted in *lumpi* as anterior antennae, but which Thor suggests may be mandibles (?). On the dorsal surface beneath the skin are a pair of small hooks, regarded as rudimentary antennae. Near the mouth on the ventral surface are two large papillae and two much smaller ones, regarded as rudimentary mouth parts. The ends of the

hammer are wart-like and there are small protuberances on the dorsal and ventral surfaces regarded as rudimentary legs (?). The neck has a length of 7-8 mm. and a diameter of 1-2.5 mm., the narrowest portion being next to the hammer and the posterior portion being much broader. The trunk or genital segment has the form of a disk, almost semicircular, thickened along the midline and around the margins, but sunken in the spaces between. The posterior margin is enlarged at the center into a prominent abdomen, completely fused with the trunk. The egg strings are 25-30 mm. long and 1-2 mm. in diameter; the branched posterior processes are almost 10 mm. long, and project beyond the lateral margins of the trunk on either side. There is great variation in the size of the hammer as well as in the processes and papillae which project from it.

Remarks.—By comparing this description with that previously given for *lumpi* it will be seen that the protuberances on the hammer are not to be interpreted as appendages of any sort, but simply as irregularities in the growth of the hammer itself. During this growth the appendages either disappear or become so small in comparison with their surroundings as to escape notice. *Lumpi* does not seem to have any such processes, but the surface of the hammer remains smooth and quite hard. This fact, combined with a great difference in the length of the neck and a smaller difference in the shape and size of the genital segment, constitutes at present the chief distinction between the two species. Until we can obtain young females, which show the details of the several appendages, and males to compare with those of *lumpi*, the two species can not be fully differentiated.

Genus REBELULA Poche.

Lophoura KÖLLIKER, Zeit. für wiss. Zool., vol. 4, 1853, p. 299.—*CORNALIA*, Atti del Soc. Italiana di sci. nat., vol. 9, 1865, p. 1.

Rebelula POCHÉ, Zool. Anz., vol. 26, 1902, p. 17.

Hepatophilus QUIDOR, Archiv. Zool. Paris, ser. 5, vol. 10, 1912, p. xliii.

External generic characters of female.—Cephalothorax cylindrical, elongate, soft, and sometimes transversely wrinkled; neck narrower than the cephalothorax, cylindrical, fully chitinized, and armed at its anterior end with short chitin knobs, large swollen processes, or profusely branched horns. Trunk or genital segment heart-shaped, flattened dorsoventrally and produced posteriorly into a pair of broad lateral lobes, with a much smaller pair inside of them at the bases of the egg strings; abdomen represented by a median unpaired lobe fused with the trunk and projecting more or less. A pair of posterior processes, covered with respiratory cylinders, attached to the dorsolateral surface of the abdomen. Egg strings longer than these processes; eggs small and multiseriate. First antennae reduced

to minute knobs; second pair in the form of spherical processes; proboscis projecting very little; first maxillae reduced to tiny knobs, tipped with a single spine; maxillipeds and swimming legs not visible in the matured adult.

Internal generic characters of female.—Esophagus bent into an S curve, entering the stomach at the anterior end; stomach not much enlarged, passing insensibly into the intestine, which is narrowed into a thread in the neck, widened in the genital segment, and abruptly contracted into a short rectum in the abdomen. A system of profusely branched processes connected with the anterior portion of the intestine in the trunk. Cement glands at the extreme postero-lateral margins of the trunk, not segmented; ovaries just in front of the cement glands; oviducts coiled inside of the cement glands, coils not separated by muscles, but the latter are grouped in bundles, usually two anterior and two posterior; no excretory glands visible.

External generic characters of male.—Cephalothorax short, without a carapace but with a large spherical swelling on either side of the dorsal surface, containing the testis. Thorax distinctly segmented, the segments increasing in size posteriorly; no abdomen but a small lobe at the posterior end of the genital segment on either side, tipped with a long, stout spine. First antennae uniramous and segmented; second pair uncinata, with a rudimentary endopod; first maxillae biramous, rami one-jointed; second maxillae made up of a single joint, tipped with a strong claw; maxillipeds with elongate basal joints, completely fused, terminal joints separate and tipped with powerful claws.

Internal generic characters of male.—Esophagus inclined to the head axis, entering the stomach at the anterior end on the ventral surface; stomach not much enlarged, passing insensibly into the intestine, which runs straight through the center of the body to the anus. Testes paired and spherical, situated in the back of the head; sperm ducts leading from their posterior ends along the center of the lateral margins to the large spermatophore receptacles in the genital segment. The cement glands surround the posterior portion of the sperm ducts; a single large maxillipedal gland in the fused bases of the maxillipeds; a small three-lobed gland on either side of the intestine in the third thorax segment; a still smaller one on either side of the intestine near the anus; minute median glands on the ventral surface of the first and fourth segments and the dorsal surface of the second segment, and a long frontal gland above the stomach near the anterior end of the head.

Type of the genus.—*Rebelula edwardsii* (Kölliker), monotypic. (*Rebelula*, to Dr. H. Rebel, of Vienna.)

Remarks.—The distinguishing characters of this genus in the female are the soft cylindrical cephalothorax, the narrow chitin neck with its armature of knobs, processes or horns, the posterior processes covered with respiratory cylinders, and the profusely branched intestinal outgrowths in the anterior trunk. In the male the characteristic features are the oblique truncation of the head, the spherical enlargements for the testes, and the elongated fused basal joints of the maxillipeds.

The genus was first described under the name *Lophoura* by Kölliker in 1853; Claus added some details and gave a figure of the adult female in 1860, and in 1865 Cornalia published a detailed account with numerous figures, both of which were so accurate as to leave no doubt of the identity of the species. Poche in 1902 called attention to the fact that the name *Lophura* had been preoccupied for a genus of birds in 1822 and a genus of reptiles in 1840, and suggested the name *Rebelula* as a substitute.

In 1912 Brian in the *Resultats des Campagnes Scientifiques du Prince de Monaco*, Fascicle 38, again described (p. 28) and figured (pl. 4, figs. 3 and 4; pl. 8, fig. 4, *a-d*) Kölliker's species, which had been obtained from *Macrourus atlanticus* Lowe, in the Bay of Biscay. He found a number of differences in the details of the head and neck, and discovered the maxillae behind the mouth tube, but failed to find any of the other appendages.

In the same year Quidor discovered what he claimed to be a new genus upon a *Macrourus* from the Sudan coast in Africa, and which he named *Hepatophylus*. This proves to be not a new genus, but a new species of the present genus, and is identical with those enumerated below from the same host. Males of this genus are here described for the first time.

ARTIFICIAL KEY TO THE SPECIES.

- Cephalothorax short, wide, transversely wrinkled; neck armed with branched horns; genital segment obcordate; posterior processes long and covered with cylinders.....*cornuta*, new species, p. 582.
 Cephalothorax long, wide, smooth; head separated by a deep constriction; neck armed with four unbranched knobs; genital segment quadrate; posterior processes short, covered with cylinders....*edwardsii* (Kölliker), 1853, p. 536.
 Cephalothorax long, narrow, smooth; neck armed with three spherical processes or four short, unbranched horns; genital segment obcordate; posterior processes short, covered with cones.....*bouvieri* (Quidor), 1912, p. 579.
 Cephalothorax filose, ten times as long as wide; neck twisted and armed with small, irregular knobs; posterior processes short and covered with cones.
gracilis, new species, p. 585

REBELUA BOUVIERI (Quidor).

Plate 53, figs. 34-40; plate 54, figs. 41-44.

Hepatophylus bouvieri QUIDOR, Archiv. Zool., Paris, ser. 5, vol. 10, 1912, p. xliii, figs. 5 and 6, text.

Host and record of specimens.—The collection of the National Museum contains 25 females and 1 male of this species, all obtained by the Bureau of Fisheries steamer *Albatross* from the common rattail, *Macrourus bairdii*, of the deep Atlantic and numbered as follows:

Specimens.	Station.	Locality.	Date.	Cat. No. U.S.N.M.
1 female.....	895	Off Marthas Vineyard.....	1880	6127
Do.....	1029	do.....	1881	6128
Do.....	1140	do.....	1882	6129
Do.....	894	do.....	1880	6130
Do.....	894	do.....	1880	6131
Do.....	894	do.....	1880	6133
Do.....	1029	do.....	1881	6134
Do.....	894	do.....	1880	6135
Do.....	895	do.....	1880	6136
2 females.....	2212	Off New Jersey.....	1884	42340
1 female.....	2202	do.....	1884	42344
Do.....	2212	do.....	1884	45731
Do.....	1096	Off Marthas Vineyard.....	1882	49749
2 females.....	2212	Off New Jersey.....	1884	49750
3 females.....	2202	do.....	1884	49751
1 female.....	2179	do.....	1884	49752
2 females.....	2186	do.....	1884	49753
1 female.....				49765
Do.....	2189	Off New Jersey.....	1884	49766
1 male, 1 female....	1153	Off Marthas Vineyard.....	1882	49748

The anterior portion of the parasite was buried in the flesh of the host beside or behind the dorsal fin, with only the genital segment and egg strings visible. A large cyst was formed around the head and neck, and in the case of No. 49748, whose host was only 7 inches in length, the cyst was so large that it bulged out on both sides of the body. Quidor reported two specimens from the same host, and this was true of No. 49750, but in all the other instances there was but a single parasite on a host.

Specific characters of female.—The cephalothorax of this species is cylindrical, four times as long as wide, and tapers gradually toward the tip. The surface is perfectly smooth and devoid of wrinkles. Near the tip is a groove where all the longitudinal muscles are interrupted, and which separates a terminal portion, of about the same length and width, representing the head. The extreme anterior portion of this head is again separated by a groove which extends from the posterior base of the second antennae to the maxillipeds on the ventral surface. The end of the head, distal to this groove, shows five rounded processes, two dorsal, two ventral, and one median, all more or less fused together.

Behind the cephalothorax is a slender neck, one-third the diameter of the cephalothorax and of varying length. This is fully chitinized and its surface is in some specimens perfectly smooth, in others raised into knobs irregularly disposed. It is attached to the center of the anterior end of the genital segment. At the point of junction of the cephalothorax and neck in all the specimens above enumerated are three large spherical processes, two lateral and one dorsal. The diameter through these processes is three times that of the cephalothorax and nine times that of the neck. Quidor found at this point "four cornes, deux dorsales et deux ventrales, dirigees obliquement vers l'arriere, de haut en bas et longues de 3 mm." (p. xliii). But as this is the only difference between his specimens and the present ones, it does not seem sufficient to constitute a separate species. The processes are smooth, with a thick chitinous skin and evidently serve the same purpose as the short horns that Quidor found, namely, the anchoring of the parasite to its host.

The dorsal and ventral surfaces of the genital segment show pits or depressions on either side between the midline and the lateral margin. These pits are of various sizes, numbers, and arrangement, but are most usually four in number, two anterior and two posterior, shaped like parenthesis marks. They are undoubtedly the "deep depressions, funnel-shaped and semilunar" noted by Cornalia at the posterior end of the genital segment, and which he found to be connected on the inside with a strong muscle band. He did not notice or did not mention the anterior ones. But his explanation of them as sucking disks for prehensile purposes is plainly erroneous. The muscles are like those in *Sphyrion*, only here they are gathered in bundles instead of being scattered promiscuously, and the pits on the dorsal and ventral surfaces correspond to the ends of the muscle bundles. When placed in preservatives the muscles usually contract, producing the pits, but they sometimes remain relaxed and then the surface of the genital segment is smooth, although the attachment of the muscles can still be seen through the skin.

The genital processes at the posterior end of the segment are on a level with the ventral surface, and each is double, consisting of a dorsal and ventral portion, between which is the opening of the oviduct. The two portions are not in line and so appear double whatever the point of view. From the ventral portion projects a small knob, at whose tip is the opening of the duct leading to the sperm receptacle.

The egg strings are comparatively very large, as long as the entire body and one-third as wide as the genital segment; they taper toward the tip, which is bluntly rounded. The eggs are minute; they are not arranged in regular rows, but there are between 75 and 100 in a cross section of each string, while lengthwise there are from 225 to 250.

This gives a total of 15,000 to 20,000 for each string. Such an exceptional number is explained when we recall that the host of this parasite is a deep-sea fish, living at a considerable depth, which adds greatly to the difficulty experienced by the larva of the copepod in finding a host.

The abdomen is on a level with the dorsal surface of the genital segment; it has the form of a spherical knob, split lengthwise at the tip by the anus. It is completely fused with the genital segment, and from the fused dorsal surface arise the posterior processes. These are covered, not with true cylinders, as in *R. cornuta* and *R. edwardsii*, but with elongated cones which taper from the point of attachment to the distal end. This end is sometimes enlarged and more or less spherical and sometimes divided into two short branches. Each process carries about 40 or 50 of these cones.

The first antennae are reduced to tiny knobs on the dorsal surface of the head; the second antennae are probably replaced by the spherical processes at the anterior margin of the head, although in the adult they have lost all traces of appendages. The mouth tube is on the front of the head and ventral to these processes; it does not project from the surface, but is supported by a chitin framework provided with muscles which probably make it more or less protrusible. On either side of the mouth is a small rounded papilla, tipped with a spine, which represents the first maxilla. Ventral to the mouth is a similar pair of small knobs, each tipped with two spines, which are the second maxillae. Farther back on the ventral surface at the base of the fused ventral processes and in front of the groove differentiating the head is a pair of rudiments which probably represent the maxillipeds. They correspond in position with those of *Sphyrion*, but for certainty younger stages of the female must be examined.

On examining the internal morphology of the trunk we find the anterior portion of the enlarged intestine covered with processes. These are apparently arranged in longitudinal rows like those in *Sphyrion*, but the anterior ones are many times the length of the posterior ones and are profusely branched, so that they fill the entire cavity of the trunk for the anterior fourth of its length, and their tips are flattened against the inside of the walls of the trunk. They then diminish rapidly and regularly in length and in complexity of branching and cease at about the center of the trunk. They thus form a conical mass filling the entire anterior diameter of the trunk and then tapering down to the diameter of the intestine. No dorsoventral muscles can be seen in this portion of the trunk, but there is a bundle of them just behind these processes near the lateral margin and another farther back and nearer the intestine. The cement glands are at the posterolateral margins of the genital

segment; they are narrow, curved in the form of parenthesis marks, and are not segmented. The ovaries are inside the cement glands, and the oviducts are coiled back and forth in the space between the cement glands and the intestine.

Color (preserved material), a uniform yellow-gray, deepened into brown in the neck and genital segment and into orange in the egg strings. Total length, exclusive of the posterior processes, 30–40 mm. Cephalothorax, 10–15 mm. long, 2.50–3 mm. wide. Neck, 10–15 mm. long, 0.50 mm. wide. Trunk, 10–15 mm. long, 6–10 mm. thick, 8–12 mm. wide. Posterior processes, 7–9 mm. long. Egg strings, 30–40 mm. long, 3–4.50 mm. wide.

Specific characters of male.—In the male of this species the front of the head is not as obliquely truncated as in *cornuta*, the swellings on the dorsal surface which contain the testes do not project as prominently, and the posterior part of the head is relatively much thinner; the fused basal joints of the maxillipeds are not as thick or as long, the thorax is relatively shorter and narrower, and the stout conical spines at the posterior end of the genital segment are replaced by a pair of tiny knobs. Internally each testis reaches around the side of the intestine almost to the ventral surface and the cement portion of the sperm duct is relatively larger, especially in the third and fourth segments.

The first antennae are three-jointed, but the terminal and basal joints are short, and the basal joint is not flattened laterally. In the second antennae the three basal joints are about the same length, but diminish regularly in width; the cylindrical process of the second joint is given off at the base of the joint instead of the distal end, and all the joints are relatively shorter than in *cornuta*.

The first and second maxillae are the same as those of *cornuta*, but the terminal claw of the maxillipeds is not as stout, and the second joint is armed with three short spines.

Color (preserved material), a uniform yellow-white. Total length, 3 mm. Diameter of back of head, through the testes, 0.51 mm. Dorsal ventral thickness of same, 0.51 mm. Diameter of genital segment, 0.50 mm.; thickness, 0.25 mm.

(*bouvieri*, to Prof. E. L. Bouvier.)

REBELULA CORNUTA, new species.

Plate 55.

Host and record of specimens.—A single female with attached male was obtained off Ochiishi Saki, at the eastern end of Hokkaido, Japan, from the flesh on the side of a *Synaphobranchus affinis* Gunther, dredged from a depth of 359 fathoms by the Bureau of Fisheries steamer *Albatross*, October 3, 1906. The female has been given

Cat. No. 49758 U. S. N. M., and becomes the type of the new species; the male was cleared in clove oil and mounted.

Specific characters of female.—Cephalothorax soft, cylindrical, the same diameter throughout, and transversely wrinkled; it is squarely truncated anteriorly and surrounded by a raised margin, broken on the ventral surface but continuous elsewhere. Neck narrower than the cephalothorax and fully chitinized, bearing on its anterior end four profusely branched chitin horns, arranged approximately at the four angles of a square. Each horn has a thick base which is immediately divided into two branches, the division taking place so close to the surface of the neck that it might be said there were eight horns arranged in pairs. The branches are irregular, long, and slender and twisted until they are more or less parallel with the neck; they are bluntly rounded at the tips. Behind the horns the neck is smooth, hard, and thick-skinned, and within a short distance is bent at right angles ventrally; it is then straight and of uniform diameter until just before it reaches the genital segment, where it is slightly narrowed and joins the latter at its anterior end and at right angles to the ventral surface. These two flexures being in the same plane leave the head and anterior neck parallel with the trunk axis and directed backwards.

The trunk is elongate obcordate, flattened dorsoventrally, the narrow end joined to the neck, the wide posterior end rounded into a broad lobe on either side and slightly reentrant at the center. On the dorsal and ventral surfaces are wide, deep grooves on either side half way between the midline and the lateral margin. Along the bottom of each groove is a row of five or six shallow pits. Inside of the lateral lobes at the posterior end are the genital processes, which are spherical and close to the median line, and from whose inner, distal corners are given off the egg strings. The abdomen has the form of a spherical knob split at the end by the anus, and projects from the center of the posterior end of the trunk dorsal to the genital processes. To its dorsolateral margins are attached the posterior processes, which are stout and as long as the trunk, each bearing about 75 respiratory cylinders, which increase in length distally. Each cylinder is contracted where it joins the process into a short filose neck, usually bent at right angles, so that the cylinder trails back in the water nearly parallel with the process. The rest of the cylinder is of the same diameter, is 10 to 15 times as long as wide, and the free end is bluntly rounded and without enlargement or division. The egg strings were lacking in the single specimen obtained.

In the center of the anterior end of the cephalothorax are the second antennae, which are swollen, finger-like processes, somewhat resembling those of *Sphyrion*, but relatively smaller. On their tips

are two minute papillae, all that is left of the chela. Dorsal to the bases of these antennae is a pair of small knobs which represent the first antennae; ventral to them is the mouth opening, which does not show any maxillae.

Color (preserved material), yellowish gray tinged with brown on the neck and genital segment.

Total length, excluding the posterior processes, 32 mm. Cephalothorax, 3 mm. long, 1.66 mm. wide. Neck, 1.66 mm. in diameter. Trunk, 15 mm. long, 10 mm. wide at the posterior end. Posterior processes, 20 mm. long, 15 mm. wide.

Specific characters of male.—The anterior end of the head is cut at an angle of 45° with the body axis, and on the flattened disk thus produced are the two pairs of antennae, the mouth tube, and the first maxillae.

The antennae are attached about two-fifths of the distance from the lateral margin to the center of the disk, the anterior pair slightly nearer together than the posterior, both pairs projecting at right angles to the surface of the disk. Each anterior antenna is three-jointed, the basal joint as long as the other two, three times as wide, and flattened laterally, carrying on its inner surface a long slender seta. Each posterior antenna is four-jointed, the second and fourth joints about the same length, the basal one shorter and wider; the second joint carries on its posterior margin near the distal end a narrow cylindrical process, tipped with a single long seta; the terminal joint is armed with a small claw. The mouth tube projects as a regular proboscis, similar in all respects to those of the Lernaepodidae. At its base on either side is a maxilla made up of a stout basal joint and two 1-jointed rami of the same size, each of which is tipped with two setae. The sides of the second maxillae project inward in the form of a broad flap or lamina at the base of the terminal claw. The terminal joints and claws of the maxillipeds project at the tip of the long fused basal joints like the jaws of a chela on a long handle. The ends of the basal joints between the claws are armed with short and stout spines.

Color (preserved material), a uniform yellow-white.

Total length, 2.25 mm. Greatest diameter, 0.66 mm.

(*cornutus*, horned, alluding to the attachment horns on the neck of the female.)

Remarks.—The distinguishing characters of this species are the profuse armature of branched horns on the neck of the female and the peculiar diagonal truncation of the head in the male. To these may be added the double flexure of the neck and the transverse wrinkling of the cephalothorax, the elongation and shape of the trunk, the length of the posterior processes, and the large number of cylinders, all belonging to the female. In the male the testes at

the back of the head protrude much more than in *bouvieri*, the maxillipeds are considerably longer, while the spines at the posterior end of the body are shorter and smaller. When taken in connection with the differences in the details of the appendages these characters serve to establish the species. The single specimen obtained does not necessarily mean that the species is scarce, because its host is a deep-sea fish, and not many specimens have been examined for parasites.

REBELULA GRACILIS, new species.

Plate 53, fig. 33; plate 54, fig. 45.

Host and record of specimens.—Two females, one with egg strings and the other without, were obtained by the Bureau of Fisheries steamer *Albatross* off Marthas Vineyard in 1882 from *Synphobranchus pinnatus*. The first of these is made the type of the new species with Cat. No. 49754, U.S.N.M.; the other becomes a paratype, with Cat. No. 49755, U.S.N.M. Another species without egg strings was obtained off New Jersey by the Bureau of Fisheries steamer *Albatross* in 1884 from *Histiobranchus infernalis*, and has been given Cat. No. 49756, U.S.N.M. A fourth specimen, also without egg strings, was obtained at the same time and place from *Synphobranchus pinnatus*, and was numbered 6126, U.S.N.M.

Specific characters of female.—Cephalothorax narrow and from 10 to 15 times as long as wide, transversely wrinkled posteriorly but smooth anteriorly, the smooth part considerably wider than the wrinkled portion, which passes insensibly into the chitinous neck. Head separated from the rest of the cephalothorax by a deep groove, as in *edwardsii*; neck very slender anteriorly, bent and twisted in different directions, considerably thickened, and straight posteriorly. It is armed on the slender portion, about one-third of its length from the anterior end, with several irregular chitin knobs, whose combined diameter is not more than three times that of the neck itself. The neck joins the anterior end of the genital segment, usually at an obtuse angle with the dorsal surface of the latter. Trunk comparatively large and thick, obcordate, but much wider anteriorly than in *cornuta*, namely, three-fourths as wide and half as thick as long. The pits on the dorsal and ventral surfaces are but little sunken in any of the specimens and their edges usually protrude a little.

The lateral posterior lobes are practically lost in the general contour of the trunk; the genital processes are small and spherical. The posterior processes are a little more than half the length of the trunk and are covered with elongated cones, which are enlarged but not divided at their tips, and are all about the same length. The egg strings are as long as the entire body, but much narrower than in *bouvieri*; the width less than one-twentieth of the length.

The head is a narrow lobe at the anterior end of the cephalothorax, less than half the width of the latter, and somewhat three-cornered in both dorsal and ventral views, widest along the anterior margin and narrowing to a rounded point posteriorly. From the center of the anterior margin project the second antennae, which are rather small transverse ellipsoids. Between these and the dorsal surface of the head, and entirely concealed by them, are the small knobs representing the first antennae.

On the ventral surface of the head, a short distance behind the bases of the antennae, is the mouth opening. On either side of this and some distance from it are the first maxillae, and behind the opening are the second maxillae, close together on the midline. On either side of the head is a large pad-like process, curved both dorsally and ventrally, and ending in bluntly rounded points, those of the two processes not quite meeting on the dorsal and ventral surfaces.

Color (preserved material), a yellow-white; the neck and trunk with a brownish tint, the egg strings a deep orange.

Total length, including the posterior processes, 55 mm. Cephalothorax, 15 mm. long, 1-1.50 mm. in width. Neck, 15 mm. long, 0.50 mm. wide anteriorly, 1 mm. wide posteriorly. Trunk, 15 mm. long, 12 mm. wide, 8 mm. thick. Posterior processes 10 mm. long. Egg strings 42 mm. long, 2 mm. wide.

(*gracilis* slender.)

Remarks.—The distinguishing characters of this species are the narrow and elongated cephalothorax, neck, and egg strings, the tiny three-cornered head, the twisting of the neck and its armature of small, irregular knobs, and the large and plump trunk. The two hosts upon which it was found are closely related fishes of the deeper portions of the Atlantic.

REBELULA EDWARDSII (Kölliker).

Lophoura edwardsii KÖLLIKER, Zeit. für wiss. Zool., vol. 4, 1853, p. 299.

Lophoura edwardsii CORNALIA, Atti del soc. Italiana di Sci. Nat., vol. 9, 1865, p. 1.

Host and record of specimens.—Kölliker's specimens were secured at Messina from the body of a *Lepidoleprus caelorhynchus*, while Cornalia's were taken from the same host at Naples. The latter were fastened in the flesh above the vertebral column, the head passing in between the spinous apophyses of the vertebrae to the dorsal aorta.

Specific characters of female.—The following account is adapted from Cornalia, who has given us the best description of the species. The anterior part of the body is made up of a soft cylinder, about 1 mm. in diameter, with a roughened skin. The extreme tip of the cylinder may be regarded as the true head, and it is separated from

the part behind it by a narrow constriction forming a sort of neck. This head carries five nonarticulate, fleshy projections, arranged in pairs with a single, unpaired one in the center. The anterior pair are a little smaller and closer together, while the posterior pair are larger and farther apart; the mouth is just behind the central, unpaired projection. The rest of the cylinder is of the same diameter as the head and without appendages.

Behind this cylinder is the neck, 0.20 mm. in diameter, and joining both the cylinder and the trunk abruptly. Just behind the cylinder the neck is armed with four short, bluntly rounded processes, extending out at right angles to the neck axis like four diagonals of a square.

The trunk is rectangular, a little longer than wide, with rounded corners, and flattened dorsoventrally. The skin covering it is smooth, chitinous, and rather thick, showing plainly the attachment of the four bundles of dorsoventral muscles, two anterior and two posterior. From the center of the posterior margin of the trunk projects the spherical abdomen, and on either side of this is a smaller genital process, out of which opens the oviduct. To the abdomen are attached the posterior processes, each composed of a central filiform shaft, carrying, at short intervals, the respiratory cylinders, of which the anterior two or three are shorter than the rest. There are 16 to 18 of these cylinders on each process, and they are all of the same diameter, which is a little greater than that of the neck, and have bluntly rounded ends, which are neither swollen nor divided.

Color whitish, tending to yellow; darker on the neck and trunk. Total length, including the posterior processes, 29 mm. Cephalothorax, 4 mm. long, 1 mm. wide. Neck, 6 mm. long, 0.20 mm. wide. Trunk, 9 mm. long, 8 mm. wide. Posterior appendages, 10 m. long.

(*edwardsii*, to H. Milne Edwards.)

Remarks.—While Cornalia's description is in the main correct, there are one or two points that require notice. Neither Cornalia nor Claus, who had added¹ some important observations with reference to "*Lophoura*," knew how to interpret the four processes on the neck. Claus even went so far as to say that they were nothing but the chitinized ends of the ventral muscle strands, which stood out at this point as small ridges in consequence of an injury. Cornalia criticized this interpretation, but offered nothing in its place.

In Cornalia's specimens the muscle fibers in the center of the dorsoventral bundles in the trunk are strongly contracted, while those around the margin of the bundles remain relaxed. This drew in the body wall at the center of the bundle and formed a "deep

¹ Wurzbürger naturwiss. Zeitsch., vol. 1, 1860, p. 20.

depression, funnel shaped and semilunar, the lumen of which is occupied by a chitinous lamina."

This was interpreted as a sort of sucker for prehension, but of course performs no such function as that.

In endeavoring to locate the genus *Cornalia* called attention to the resemblance between *Sphyrion* and "*Lophoura*" in the general make-up of the body, and between "*Lophoura*" and *Haemobaphes* in their mode of attachment to their host and in the body divisions.

Genus TRYPAPHYLUM Richiardi.

Lerneonema, part, P. J. VAN BENEDEN, Ann. Sci. Nat., ser. 3, vol. 16, 1851, p. 125, pl. 6, figs. 11 and 12; Bull. Acad. Belgique, vol. 18, 1851, p. 287, pl. 1; L'Institut, vol. 19, 1851, p. 285.

Lerneonema VOGT, Recherches Cotières, 1877, p. 69, pl. 3, fig. 11, male.

Trypaphylum RICHARDI, Atti del Soc. Toscana, vol. 1, 1878, p. xx.

Lernaecenicus BASSETT-SMITH, Proc. Zool. Soc. London, 1899, p. 485.

Tripaphylus CARUS, Prod. Faunae Mediterraneae, 1885, p. 372.

Tripaphylus T. and A. SCOTT, British Parasitic Copepods, 1913, pp. 160 and 229, pl. 45, fig. 6; pl. 51, fig. 1; pl. 49, figs. 1-7.

Generic characters of female.—Body slender and greatly elongated, without segmentation. Cephalothorax rounded and provided with stiff cartilaginous horns. Free thorax forming a long and slender neck, filiform anteriorly, considerably widened posteriorly. Trunk narrowed anteriorly to the width of the neck, widened posteriorly and furnished with two long and slender posterior processes, which are straight, cylindrical, and smooth like those in *Paeon* and *Opimia*. Antennae and mouth parts similar to those of *Lernaecenicus*.

Generic characters of male.—Cephalothorax slender, conical, without a carapace and with no external indication of the testes. Thorax indistinctly segmented anteriorly, completely fused posteriorly; genital segment swollen and tipped with a pair of slender conical processes; no abdomen. First antennae uniramous, indistinctly jointed; second pair biramous, the exopod chelate. Mandibles with strong curved teeth at the tip like those in the *Lernaepodidae*. Basal joints of second maxillae and maxillipeds fused, terminal joints free and armed with strong chelae.

Type of the genus.—*Trypaphylum musteli*, monotypic.

(*Trypaphylum*, τρυπάω, to bore and φύλον, race or tribe.)

Remarks.—In 1851 P. J. van Beneden established a new species which he named *musteli* and referred to Milne Edwards's genus *Lerneonema*. He obtained it from the gills and pharyngeal cavity of *Mustelus vulgaris* on the Belgian coast. Later in the same year he published a more complete account of the species. Vogt in 1877, reviewing Beneden's description and figures, said that the male showed that the genus belonged to the *Lernaepodidae*. Bassett-Smith in 1899 assigned the species to the genus *Lernaecenicus* without

giving any reason for such action. Richiardi in 1878 claimed it as a new genus which he named *Trypaphylum*, but he added nothing to Beneden's description. It was enumerated under this new name, with a change in the spelling, by several subsequent authors, including T. and A. Scott. In their excellent monograph on British Parasitic Copepods Richiardi's genus was included and a brief diagnosis of both sexes was given. From this account the present author has borrowed very freely and acknowledges his deep indebtedness. Unfortunately, no description has ever been given of the antennae and mouth parts of the female, and in all the figures that have been published the head of the female has been lacking. We are thus prevented from locating the female exactly, but if the male, which was admirably described and figured by the two Scotts, is of the same species it shows beyond a doubt that the genus does not belong to the Lernaeidae. No Lernaeon male lives long enough to appear with the female on the final host, nor does it bear any resemblance to this *Trypaphylum* male. And the differences between this male and those belonging to the Lernaeopodidae are just as great.

On the other hand, there is a close similarity between the male described by the Scotts and the two here given for the genus *Rebelula*. Indeed, the only difference is the lack in the former of the prominences at the back of the cephalothorax, containing the testes; but this is more than offset by the elongation and complete fusion of the basal joints of the second maxillae and maxillipeds. It is also worthy of note that at the time the species was originally established Beneden called attention to its close affinity with the genus *Sphyrion*, and several other authors have commented on this same relation. Accordingly, in so far as we are acquainted with the details of the structure of the two sexes, the genus *Trypaphylum* belongs with the other genera in the Sphyriidae. Only one species has ever been described, so that the genus is monotypic, but the specific name must be credited to Beneden and not to Richiardi.

Genus OPIMIA Wilson.

Opimia WILSON, Proc. U. S. Nat. Museum, vol. 35, 1908, p. 459.

Generic characters of female.—General form elongate and slender, without any traces of segmentation; cephalothorax swollen into a globe or sphere, smooth and without processes or horns. Neck cylindrical, of the same diameter throughout and two-thirds of the entire length. Trunk narrow, longer than wide, with a single pair of posterior processes, which are smooth, straight, and cylindrical; abdomen short and rudimentary.

First antennae one-jointed papillae; second pair stout, uniramous, and uncinat; mouth tube terminal, protruding; one pair of maxillae;

maxillipeds well developed and tipped with strong claws; one pair of swimming legs close behind the maxillipeds. Male unknown.

Type of the genus.—*Opimia exilis* Wilson, monotypic.

(*Opimia*, a vestal virgin unfaithful to her vow.)

Remarks.—When first established this genus was placed with the Lernaeidae, since its near relatives belonged there. But at the revision of the Lernaeidae¹ it was decided that *Opimia* and its relatives could no longer remain in the family, and accordingly the present new family has been formed to include them. *Opimia* is very close to *Trypaphylum* and the new genus *Pacon*, and the three differ from *Sphyrion* and *Rebelula* chiefly in the fact that the posterior processes are unbranched and are not covered with respiratory cylinders or cones. The distinguishing characters of the genus are the smooth cephalothorax without processes or horns, the stout maxillipeds, and the single pair of swimming legs.

PAEON, new genus.

External generic characters of female.—Body separable into three regions—cephalothorax, neck, and trunk; cephalothorax enlarged into a transverse ellipsoid whose surface is produced into paired processes. Neck slender and nearly straight, but showing considerable torsion. Trunk swollen, flattened dorsoventrally, and furnished posteriorly with a pair of long and slender processes dorsal to the egg strings; abdomen minute with a pair of globular anal laminae, and completely fused with the genital segment. Egg strings straight; eggs multiseriate. No antennae visible; proboscis retractile; a pair of biramous maxillae on the sides of the mouth tube; a second pair of maxillae behind the mouth, one-jointed and armed with stout claws; no swimming legs.

Internal generic characters of female.—Esophagus inclined and entering the stomach on its ventral surface near the anterior end; stomach not much enlarged, without lobes or processes, passing insensibly into the intestine, which is filose in the neck, is enlarged, but without processes, in the trunk, where it is nearer the dorsal surface, and is contracted into a short rectum, which opens between the anal laminae. Ovaries paired, at the sides of the genital segment in front of the cement glands; oviducts coiled transversely, the coils kept in place by strands of dorsoventral muscles. Cement glands at the posterolateral corners, close to the body wall, unsegmented, with short ducts. Body wall thin and not chitinized.

External generic characters of male.—Cephalothorax elongate and covered with a carapace; second thorax segment well separated; third, fourth, and fifth segments fused more or less completely, and

¹ Proc. U. S. Nat. Mus., vol. 53, pp. 1-150.

armed posteriorly with a pair of long conical processes tipped with spines; no abdomen.

First antennae indistinctly jointed; second pair bipartite at the tip; first maxillae on the sides of the mouth tube; second pair stout and uncinatc; maxillipeds also stout, their basal joints fused, the terminal joints chelate.

Internal generic characters of male.—Espohagus in line with the head axis and opening into the anterior end of the stomach on its ventral surface. Stomach passing insensibly into the intestine, which is abruptly contracted into a short rectum at the posterior end of the genital segment. Testes in the back of the head opposite the maxillipeds; sperm ducts running straight back on either side of the intestine and enlarged into rather small spermatophore receptacles at the posterior end of the genital segment; no glands visible.

Type of the genus.—*Paeon ferox*, new species.

(*Paeon*, a son of Posseidon.)

Remarks.—This is a genus of shark parasites found in the mouth and gill cavity, the head and long neck buried in the tissues of the host, with nothing but the soft trunk, the posterior processes, and the egg strings visible.

The head of the parasite is usually near the ventral aorta of the host, and the irritation caused by the burrowing forms a well-defined cyst around the copepod's head and neck, which stiffens the tissue and adds considerably to the effectiveness of the attachment.

The head and neck are tough and leathery and yet soft enough to yield readily to pressure, so that when endeavoring to remove the creature from the cyst the head will often squeeze out of a small cut, apparently all out of shape. But the elasticity of the tissue restores the normal shape perfectly as soon as the pressure is removed. The trunk and posterior appendages are soft and much less elastic, and it is hence very difficult to preserve the animal in its normal form. They must be kept straight and extended in the preservative in the same way that cestodes and similar material are handled. In water they are capable of considerable motion, writhing about like a worm and coiling and uncoiling their long necks and bodies. By this means they can move about over the bottom of the vessel containing the water and can even raise themselves off the bottom to some extent. But they only live from 36 to 48 hours under such conditions, and it is not at all probable that they ever have occasion to use this form of motion under natural conditions.

KEY TO THE SPECIES.

- Head obcordate; neck much wrinkled; trunk also obcordate, as wide as long,
versicolor, new species, p. 596.
 Head transversely elliptical; neck rather smooth; trunk much longer than
 wide, squarely truncated posteriorly-----*ferox*, new species, p. 592.

PAEON FEROX, new species.

Plate 56; plate 57, figs. 60, 61, 63, 64, 66.

Host and record of specimens.—Twelve females, two of them with attached males, were obtained by the author from the gill cavity of the sharp-nosed shark, *Scoliodon tetrarhynchos*, in July, 1905, at Beaufort, North Carolina. These have been divided into three lots—the first, a single female with egg strings, is made the type of the new species with Cat. No. 47824, U.S.N.M. Four other females become paratypes with Cat. No. 47825, U.S.N.M., and the remaining seven are also made paratypes with Cat. No. 47826, U.S.N.M.

External specific characters of female.—Cephalothorax enlarged transversely by a pair of hemispherical lateral processes into a tolerably regular ellipsoid, upon the anterior and ventral surfaces of which are several pairs of knobs or protuberances. One pair are dorsoventrally elliptical and extend across the anterior margin so as to be visible in a dorsal as well as a ventral view. Their adjacent surfaces meet on the midline and are flattened together; their dorsal surfaces are about on a level with the dorsal surface of the head, but ventrally they project considerably and conceal the mouth tube. A little behind them on the ventral surface is a second pair, diagonally elliptical, with their long diameters at right angles to each other and at an angle of 45° with the axis of the head. Their outer ends are opposite the outer margins of the first pair and reach laterally a little beyond them. Their posterior margins are concave and at about the center of each, on the dorsal surface between the knob and the head itself, lies a slender finger-like protuberance, jointed near its base and divided at the tip, and looking much like a misplaced appendage. It contains what appear to be muscles and might easily have migrated to its present position during the outgrowth of the knobs.

On the anterior margin of the head between the bases of the first pair of knobs are the proboscis and mouth parts. The mouth tube is conical and protrusible, with well-defined upper and under lips like those in the male, and carries on either side a biramous maxilla. Each maxilla is made up of a short basal joint, widened dorsoventrally, and two rami. The endopod (dorsal ramus) is one-jointed and club-shaped, bluntly rounded at the larger distal end with a spine on its outer surface; the exopod is two-jointed, the terminal joint ending in a long ventral and a short dorsal spine. Just behind the mouth tube on the ventral surface of the head and in front of the oblique processes are the second maxillae. Each is stout, one-jointed, and ends in a strong claw, bent into a half circle and armed at its base on the ventral surface with a slender acuminate spine. The two are inclined toward each other so that their claws meet on the median

line, and they are evidently the chief organs of prehension. The posterior ends of the oblique knobs are connected by a ridge across the median line, which curves forward at the center.

A third pair of knobs are spherical and are situated on the ventral surfaces of the lateral processes, so far from the midline as to lie wholly exterior to the base of the neck. The ventral surface of the neck between and behind them projects strongly and on it may be seen the transverse chitin rod that probably connected the bases of a pair of swimming legs.

The neck is one-fourth the width of the head and about one-third the entire length of the body. It is of the same diameter throughout, with fairly distinct segmentation, but with no apparent traces of appendages. Where the neck joins the genital segment, which is the portion in contact with the skin of the host, it is slightly enlarged and thrown up into numerous transverse wrinkles; elsewhere it is tolerably smooth.

Within this wrinkled area the neck passes insensibly into the trunk, which then widens gradually to its posterior end, where it is about the same width as the head. The trunk is more than four times as long as wide, and at the posterior end is three times as wide as thick. Near its anterior end the division between the fourth and fifth thoracic segments is clearly indicated by a break in the longitudinal musculature and by grooves on the lateral margins. The anterior ends of the oviducts extend a short distance in front of this dividing line. The corresponding division between the fifth and genital segments is found near the anterior end of the cement glands, and still farther back is another break just in front of the anal laminae indicating the division between the genital segment and the abdomen.

The surface of the trunk is generally smooth, with a few scattered wrinkles and with small pits caused by the attachment of the dorso-ventral muscles that separate the coils of the oviducts. At the posterior end the lateral margin is produced into a rounded lobe on either side, which turns slightly downward and outward. The abdomen is so reduced that it would not be mentioned if it were not for the distinct break in the musculature. But this indicates definitely that the posterior processes are given off from the dorsal surface of the abdomen as in the other genera. Each process is one-third as long as the rest of the body, is curved like a parenthesis mark, has the same diameter throughout, and is bluntly rounded at the end. The anal laminae are swollen into knobs beneath the bases of the posterior processes and more or less fused with them. The egg strings are cylindrical and are attached to the inner margins of the posterior lobes of the genital segment; each is two-thirds as wide

and a little longer than the processes; the eggs are arranged in 9 or 10 rows which are twisted inside the tubes.

Internal specific characters of female.—Ovaries paired, one on either side, in front of and dorsal to the cement gland. Each sends out a long oviduct, irregularly coiled to the right and left and filling the space between the intestine and the lateral wall of the trunk, with the white eggs appearing at scattered intervals. The coils are separated and held in place by dorsoventral strands of muscle arranged in irregular transverse rows. In general they turn forward along the dorsal surface of the trunk and backward along the ventral surface to the vulvae, but all the convolutions are very irregular. The eggs assume nearly their full size on issuing from the ovary and then gradually mature while passing through the long oviduct.

At the posterior end of the genital segment and nearer the ventral surface on either side is a cement gland, which is long and cylindrical, the anterior end curved in toward the midline, the posterior end passing into a very short duct which empties into the oviduct near the vulva; neither gland nor duct shows any real segmentation.

A fairly thick layer of chitinogen tissue similar to that found in the Lernaeidae covers the whole lateral surfaces of the genital segment around the ovaries and fills the posterior lobes. Its inner surface is raised in small rounded elevations of irregular shapes and sizes, and in the posterior lobes it is divided similarly into irregular masses.

Color.—Head white and opaque, the knobs tipped with dark-brown pigment; neck transparent and colorless, the digestive tube and muscle bands showing opaque and white. The wrinkled section at the base of the neck is a bright crimson; the genital segment is transparent and jellylike, with a decided orange-yellow tint, the ovaries are darker and more opaque, the eggs are snow white. The posterior processes are jellylike, with a decided yellow tint; the egg strings are yellowish white, turning to a beautiful maroon on ripening. In preservatives the different regions lose their transparency and become a uniform gray-white, while the crimson patch on the neck sometimes becomes dusky, but often regains its bright crimson color after clearing in clove oil.

Total length, including posterior processes, 55 mm. Head, 3 mm. long, 4.50 mm. wide. Neck, 16.50 mm. long, 1.25 mm. wide. Trunk, 17 mm. long, 4 mm. wide. Posterior processes, 18 mm. long, 1.50 mm. wide. One specimen was 70 mm. long, with the other measurements in proportion.

Specific characters of the male.—Body plainly segmented with the regions well separated from one another. Cephalothorax considerably more than half the entire length, the anterior portion of it

covered by a carapace, which reaches back to the bases of the maxillipeds and does not extend down very far along the sides, thus leaving the mouth parts practically free. The cephalothorax is followed by a small free segment, but the remaining thorax segments are fused together with only indistinct joints.

There is no abdomen, but each of the posterior corners of the genital segment is prolonged into a conical process terminating in a short spine. These processes are close together on either side of the midline, while outside of and anterior to them is a pair of shorter processes with bluntly rounded tips, and anterior to these a pair of small knobs.

The first antennae are indistinctly three-jointed, slender, and conical, tipped with four spines, and with a few setae along the sides. The second antennae are broad and flattened, made up of a stout basal portion which is two-jointed and two terminal rami. Of the latter the endopod is one-jointed with a broad and spatulate tip armed with a single spine; the exopod is indistinctly three-jointed, the last joint carrying a pair of curved claws opposed to each other like the jaws of a chela. Inside of these second antennae on the base of the mouth tube is a pair of maxillae, each made up of a basal joint and two rami. The endopod (dorsal) is one-jointed, bluntly rounded at the tip and unarmed; the exopod is two-jointed, the terminal joint slender, flattened and tipped with two short spines. The mouth tube is relatively large and broadly conical, and extends a little way beyond the tips of the antennae; the mouth opening is surrounded by a fringe of hairs. The second maxillae and maxillipeds are very large; each is made up of three joints, the basal ones stout and armed with powerful muscles, the terminal one a strong curved claw. The basal joints of the maxillipeds are completely fused across the midline.

The testes are situated in the back of the head over the bases of the maxillipeds. The vas deferens leads along the side of the thorax to the spermatophore receptacle at the extreme posterior end of the genital segment. These receptacles are rather small and each contains but a single spermatophore with a short and nearly straight tube.

Color, a uniform snow-white.

Total length, 2 mm. Diameter of cephalothorax, 0.50 mm.

(*ferox*, fierce, bloodthirsty.)

Remarks.—This genus was obtained from the gill cavity of its host and in every instance was attached to the integument which forms the outer wall between the arches. The head and entire neck was buried in the tissues beneath this integument, the neck extending toward the nearest gill arch so as to bring the head and mouth in close proximity to one of the large arteries which sup-

ply the gills. The flattened trunk, together with the posterior processes and egg strings, hangs free in the gill cavity. It is nearly always plentifully covered with algae and various protozoa, which trail backward over the egg strings and posterior processes, binding the whole securely together. Both the neck and the head are inclosed in a very tough white membranous sheath which fits snugly and aids in holding the creature securely in place.

PAEON VERSICOLOR, new species.

Plate 57, figs. 62, 65, 67; plate 58; plate 59, figs. 75, 76.

Host and record of specimens.—Eight females, one with an attached male, were found on the inside of the mouth of the smooth hound, *Mustelus canis*, at Beaufort, North Carolina, in August, 1905. One female has been made the type of the new species with Cat. No. 49762, U.S.N.M. The other seven become paratypes, with Cat. No. 49763, U.S.N.M. Two other females were taken a week later from the same host and have been given Cat. No. 49764, U.S.N.M.

Specific characters of female.—Cephalothorax somewhat obcordate in dorsal outline, the apex being formed by the two anterior processes, the lobes by the posterolateral processes, while between these lobes the posterior margin is deeply invaginated. The two anterior processes are relatively larger than in *ferox*, are directed diagonally forward and downward, and are not produced ventrally. Their flattened inner surfaces entirely cover the proboscis and mouth parts. A pair of lateral processes project from the sides of the cephalothorax behind this frontal pair, and the bases of the two pairs are fused. The dorsal portion of the head is greatly inflated and sends out on either side diagonally backward and upward a large spherical process. The two do not quite meet on the midline dorsally, leaving a deep sinus between them. The ventral processes, instead of being diagonal as in *ferox*, are at right angles to the head axis and are fused across the midline, so that they appear as one. On the ventral surface of these processes is found on either side another jointed, finger-like proturbance similar to those in *ferox*. It, too, is solid, contains what appear to be muscles, and is split at the tip. It is on the postero-ventral instead of the postero-dorsal surface of the process, but this difference in position is probably due to the differences in the processes themselves. Whether these protuberances are really migrated appendages can only be determined by following their development, but they certainly resemble appendages. In *Sphyrion* the maxillipeds remain close to the midline, but are almost concealed by a pair of fused ventral processes just in front of them, and we might suppose that here similar processes by an increased

development have separated the appendages and carried them farther away from the midline.

The mouth tube and maxillae are similar to those of *ferox*, but the rami of the maxillae are much smaller and each is tipped with a tiny spine. The second maxillae are large and stout and are tipped with a sort of chela formed of two rounded knobs.

The neck is wrinkled for its entire length and is the same diameter throughout, which is relatively nearly twice that of *ferox*. And like the latter it shows the segmentation by breaks in the longitudinal muscles and by grooves on the lateral margins. The trunk is obovate, the neck joining its apex, and is flattened dorsoventrally, the thickness being less than a third of the width. It is as wide as long, but is made up of the same parts as in *ferox*, where the length was several times the width. Its surface is perfectly smooth, the dorsoventral muscles separating the coils of the oviducts being apparently too weak to produce any pits. The posterior processes are sausage shaped, slightly widened along the center, where they become a third of the width of the trunk. They are a fourth longer than the trunk, but are only a trifle more than half the length of the egg strings. The latter are the same diameter as the processes and are bluntly rounded at the tips. The eggs are arranged in 9 or 10 rows, with 20 to 25 eggs in each row.

The minute abdomen is set into the sinus of the posterior margin of the trunk and can be recognized only by the break in the longitudinal musculature and by the large anal laminae.

Internally the cement glands occupy the posterior corners of the trunk; they are short, somewhat curved, and about three times as long as wide. In one of the females the cement glands showed a fairly regular segmentation, but in all the others there were no indications of it. The ovaries and oviducts are arranged as in *ferox*, the convolutions of the oviducts when the eggs are fully ripe extending into the fourth segment. Chitinogen tissue fills the entire cavity of the posterior processes, but is not as abundant in the trunk and neck.

Color. lobes of the head a deep crimson, especially the posterior ones, the red set off with black around the tips of the lobes. Bases of the lobes, the central portion of the head, and the anterior neck a pale yellow; remainder of neck a bright red, deepening toward the trunk, close to which it becomes almost black. Trunk varying in different specimens, largely due to the difference in the development of the eggs, sometimes dull yellow, yellowish white, pink, or even a bright orange. Posterior processes a light gray or grayish white; egg strings creamy white, changing to lavender with development.

Total length, including posterior processes, 28 mm. Head, 3.50 mm. long, 4 mm. wide. Neck, 16 mm. long, 1 mm. wide. Trunk, 3 mm. long and wide. Posterior processes, 4 mm. long, 1 mm. wide. Egg strings, 7.50 mm. long, 1 mm. wide.

(*versicolor*, variegated in color.)

Specific characters of male.—Cephalothorax two-fifths longer than the rest of the body, with a well-rounded carapace; one free thorax segment, the rest of the body fused without traces of segmentation. Posterior processes shorter than in the *ferox* male, but ending in sharp setae. First antennae indistinctly three-jointed and tipped with two setae; second pair two-jointed, the terminal joint bifurcate, the endopod armed with two setae, the exopod ending in a chela. First maxillae uniramous, one-jointed, and ending in three stout spines; second maxillae consisting of a stout joint tipped with a strong curved claw; maxillipeds with basal joints swollen and fused across the midline, the second and third joints separate, the third joint terminated by a strong chela made up of two claws of nearly equal size, the outer one with an accessory spine at its base. Testes, sperm ducts, and spermatophore receptacles like those in *ferox*.

Total length, 1.80 mm. Diameter of cephalothorax, 0.45 mm. Diameter of body, 0.35 mm.

Remarks.—This species was always found at the corner of the first gill arch in the floor of the mouth. Two may be found in the same fish, one on either side, but no more than this and never at any other spot. The head and long neck are buried in the tissues the same as *ferox*, and are surrounded by a sheath of tough membrane.

PERIPLEXIS, new genus.

Generic characters of female.—Cephalothorax soft, cylindrical and transversely wrinkled; neck much narrower than the cephalothorax, fully chitinized, intricately bent and twisted, and armed along at least the anterior half of its length with numerous short chitin horns and processes; enlarged posteriorly and joined to the genital segment at the center of the anterior end. Trunk elongate, cordate, flattened dorsoventrally, with rows of shallow pits on the dorsal and ventral surfaces as in *Rebelula*; no posterior lateral lobes; genital processes spherical and close together, their bases joined across the midline. Abdomen spherical and minute, attached ventrally to the bases of the genital processes; posterior processes attached in the groove between the abdomen and the genital segment on the dorsal surface; each made up of three large lobes flattened together. Egg strings two-thirds as wide as the posterior processes and longer than the trunk. Head squarely truncated anteriorly and surrounded

by two crescentic pads; rudiments of first and second antennae; a retractile mouth tube with rudiments of one pair of maxillae. Male unknown.

Type of the genus.—*Periplexis lobodes*, monotypic.

(Περπλέξις, entanglement, alluding to the twisted neck.)

PERIPLEXIS LOBODES, new species.

Plate 59, figs. 77-80.

Host and record of specimens.—A single female with empty egg cases was obtained by the Bureau of Fisheries steamer *Albatross* off the coast of New Jersey in 1883 from *Alepocephalus agassizii*, a deep-sea fish captured at a depth of 1,000 fathoms. The head and neck of the parasite were buried in the flesh of its host alongside the dorsal fin. This female has received Cat. No. 49757, U.S.N.M., and becomes the type of the new species.

Specific characters of female.—In addition to the generic characters already given the cephalothorax is a little wider anteriorly and the truncated anterior end is curved over ventrally. The two excellent figures drawn by A. H. Baldwin give a good idea of the very complex twisting of the neck and its armature, which are so intricate as to baffle any description. None of the processes or horns are branched, but some of them reach a length of 5 or 6 mm., and they are all, as well as the neck itself, covered with a thick chitin skin. Behind these horns the neck enlarges gradually to a diameter of 3 millimeters and joins the trunk in line with the axis of the latter. The outline of the trunk is that of an acorn, the sides nearly parallel, contracted to the diameter of the neck where it joins the latter, and with rounded posterior corners. The width is three-fifths and the thickness two-fifths of the length; the surface is smooth and shiny save for the rows of depressions; dorsally there are seven of these pits in a row, but ventrally there are four.

The genital processes are split ventrally into three lobes, which overhang the bases of the egg strings. The egg cases are empty, but one of them is entire save for the perforations through which the larvae escaped, thus giving the size. The abdomen is relatively very small and thoroughly fused with the trunk. The posterior processes are unlike anything that has ever been reported in the parasitic copepods. Where the process is attached it is narrowed into a short, threadlike neck; this enlarges abruptly into three large lobes whose adjacent surfaces are pressed together and flattened; each lobe is two-fifths as wide and the three together are half as long as the trunk.

The two crescentic pads form a thickened rim around the truncated anterior end of the head, their bluntly rounded ends meeting

dorsally and ventrally on the midline. The first antennae are small spherical knobs on the dorsal surface of the head, behind the bases of the second pair. The latter are more or less spherical and somewhat elongated along the ventral surface, and do not show any chelate processes. In front of the bases of these antennae is the mouth tube, which is raised a little above the surrounding surface and carries on its sides a single pair of maxillae in the form of small processes tipped with a spine.

The whole structure of the head is so blind that if it were not for the suggestion obtained from a study of the immature specimens of *Sphyrion lumpyi*, and the other genera here presented, it would be almost incapable of interpretation; but analogy leaves little room for doubt.

Color (preserved material), cephalothorax and posterior processes a clear yellow; neck cinnamon brown; trunk dark gray.

Total length, including posterior processes, 60 mm. Cephalothorax 9 mm. long, 4 mm. wide. Neck 3 mm. wide posteriorly. Trunk 25 mm. long, 15 mm. wide, 10 mm. thick. Posterior processes 12 mm. long, 6 mm. wide. Egg strings 40 mm. long, 5 mm. wide. If the neck and cephalothorax were straightened it would add 15 or 20 mm. to the length.

(λοβώδης, lobed like a pod, alluding to the posterior processes.)

Remarks.—In spite of the fact that there is but a single specimen, this new species presents much of interest. It can be recognized at once by the posterior processes and the intricately twisted neck. The latter furnishes new evidence of the extent to which the burrowing and anchorage of the parasite in the tissues of its host can modify its morphology. In the other genera we have found all kinds of processes and horns. Here there is not only an extra profusion of anchor processes, but they are combined with flexures and foldings of the neck itself. Nothing short of a charge of dynamite could ever loosen this parasite's hold upon its host. In the posterior processes an increase of surface in contact with the water is obtained not by branching nor by the attachment of numerous cylinders or cones, as in other genera, but by a large increase in the diameter of the process itself. Since there was but a single specimen, nothing could be ascertained with reference to the internal anatomy; but the presence of the rows of pits on both dorsal and ventral surfaces proves the existence of dorsoventral muscle bundles similar to those in the other genera. Accordingly, we may assume that there is a corresponding similarity in other details also.

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EXPLANATION OF THE PLATES.

PLATE 50.

Sphyrion lumpi.

Fig. 1. Ventral view of adult female. Fig. 2. Dorsal view of same. Fig. 3. Dorsal view of head, enlarged. Fig. 4. Dorsal view of third development stage. Fig. 5. Ventral view of same. Fig. 6. Side view of same. Fig. 7. Dorsal view of posterior processes of same. Fig. 8. First antenna of fourth development stage. Fig. 9. Tip of second antenna of same. Fig. 10. Maxilliped. Fig. 11. First swimming leg. Fig. 12. Ventral view of head.

PLATE 51.

Sphyrion lumpi (continued).

Fig. 13. Ventral view of entire head of adult female. Fig. 14. Anterior portion of head magnified to show antennae and mouth parts; *an*¹ and *an*² antennae, *mx*¹ and *mx*² maxillae, *mxp*. maxillipeds. Fig. 15. Ventral view of youngest developmental stage obtained. Fig. 16. Dorsal view of same. Fig. 17. Dorsal view of posterior processes, just starting. Fig. 18. Dorsal view of second developmental stage. Fig. 19. Ventral view of same. Fig. 20. Dorsal view of posterior processes farther developed. Fig. 21. Second maxilla of male. Fig. 22. Maxilliped of same.

PLATE 52.

Sphyrion lumpi (continued).

Fig. 23. Side view of male; *sp.* sperm duct, *sr.* spermatophore receptacle, *t.* testis. Fig. 24. First antenna of male. Fig. 25. Second antenna of same. Fig. 26. Mouth tube and first maxilla of same. Fig. 27. First antenna of adult female. Fig. 28. Second antenna of same. Fig. 29. Second maxilla. Fig. 30. Dorsal view of trunk of youngest developmental stage. Fig. 31. Dorsal view of trunk of third developmental stage. Fig. 32. Dorsal view of trunk of adult female. In the last three figures *cl.* cement gland, *ds.* dorsoventral muscles, *ig.* processes of the intestine, just starting in fig. 30, partly formed in fig. 31, and fully developed in fig. 32, *in.* intestine, *og.* ovary, *re.* muscles controlling the rectum.

PLATE 53.

Fig. 33 Ventral view of *Rebelula gracilis*. Fig. 34. Ventral view of *R. bourieri*. Fig. 35. Side view of head of same, enlarged. Fig. 36. Dorsal view of head. Fig. 37. Ventral view of head. Fig. 38. Head viewed from the anterior end. Fig. 39. First (upper) and second antennae of male of *R. bourieri*. Fig. 40. Maxilliped of same.

PLATE 54.

Fig. 41. Side view of male of *Rebelula bourieri*; *cl.* cement gland, *eg.* excretory gland, *sp.* sperm duct, *sr.* spermatophore receptacle, *t.* testis. Fig. 42. Side view of head of adult female of *R. bourieri*, *an.*¹ antennae, *mx.*² maxillae, and *m.xp.* maxilliped. Fig. 43. Posterior end of trunk. Fig. 44. Dorsal view of trunk; *cl.* cement gland, *ds.* dorsoventral muscles, *in.* intestine, *ov.* ovary. Fig. 45. Ventral view of head of adult female of *Rebelula gracilis*.

PLATE 55.

Rebelula cornuta.

Fig. 46. Adult female. Fig. 47. Side view of male; *cl.* cement gland, *eg.* excretory gland, *sp.* sperm duct, *sr.* spermatophore receptacle, *t.* testis. Fig. 48. Ventral view of male. Fig. 49. First antenna. Fig. 50. Second antenna. Fig. 51. Mouth tube and first maxillae. Fig. 52. Second maxilla. Fig. 53. Maxilliped.

PLATE 56.

Pacon ferox.

Fig. 54. Adult female. Fig. 55. Ventral view of head, enlarged. Fig. 56. Dorsal view of head. Fig. 57. Side view of head. Fig. 58. Ventral view of trunk; *cl.* cement gland, *ds.* dorsoventral muscles, *eg.* eggs, *ms.* longitudinal muscles, *ov.* ovary. Fig. 59. Side view of male.

PLATE 57.

Pacon ferox (continued) and *P. versicolor*.

Fig. 60. Dorsal view of mouth and antennae of male; *an.*¹ and *an.*², antennae. Fig. 61. Ventral view of same. Fig. 62. Dorsal surface of trunk of *P. versicolor*; *cl.* cement gland, *ds.* dorsoventral muscles, *eg.* eggs, *in.* intestine, *ms.* longitudinal muscles, *ov.* ovary. Fig. 63. The migrated second antenna (?) of *P. ferox*.

Fig. 64. The same from another specimen. Fig. 65. The same from *P. versicolor*.
Fig. 66. Maxilliped of *P. ferox*. Fig. 67. The same of *P. versicolor*.

PLATE 58.

Paeon versicolor.

Figs. 68 and 69. Two views of adult female (owing to torsion these views are partly dorsal, partly ventral, and partly lateral). Fig. 70. Ventral view of head, enlarged. Fig. 71. Mouth tube, and first maxillae. Fig. 72. Side view of male. Fig. 73. Second maxilla. Fig. 74. Maxilliped.

PLATE 59.

Fig. 75. Side view of antennae and mouth parts of male of *P. versicolor*; *an.* antennae, *md.* mandible, *mo.* mouth, *mx.* maxilla. Fig. 76. Lateral view of head of female of *P. versicolor*. Fig. 77. Ventral view of adult female of *Periplexis lobodes*. Fig. 78. Dorsal view of same. Fig. 79. Ventral view of head, enlarged. Fig. 80. Dorsal view of same.

Figs. 1, 2, 33, and 34 were drawn by J. H. Blake. Figs. 77 and 78 were drawn by A. H. Baldwin, while figs. 4 to 11, 15 to 20, 36, 37, 42, and 43 are by Richard Rathbun.